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ELECTRICAL REVIEW

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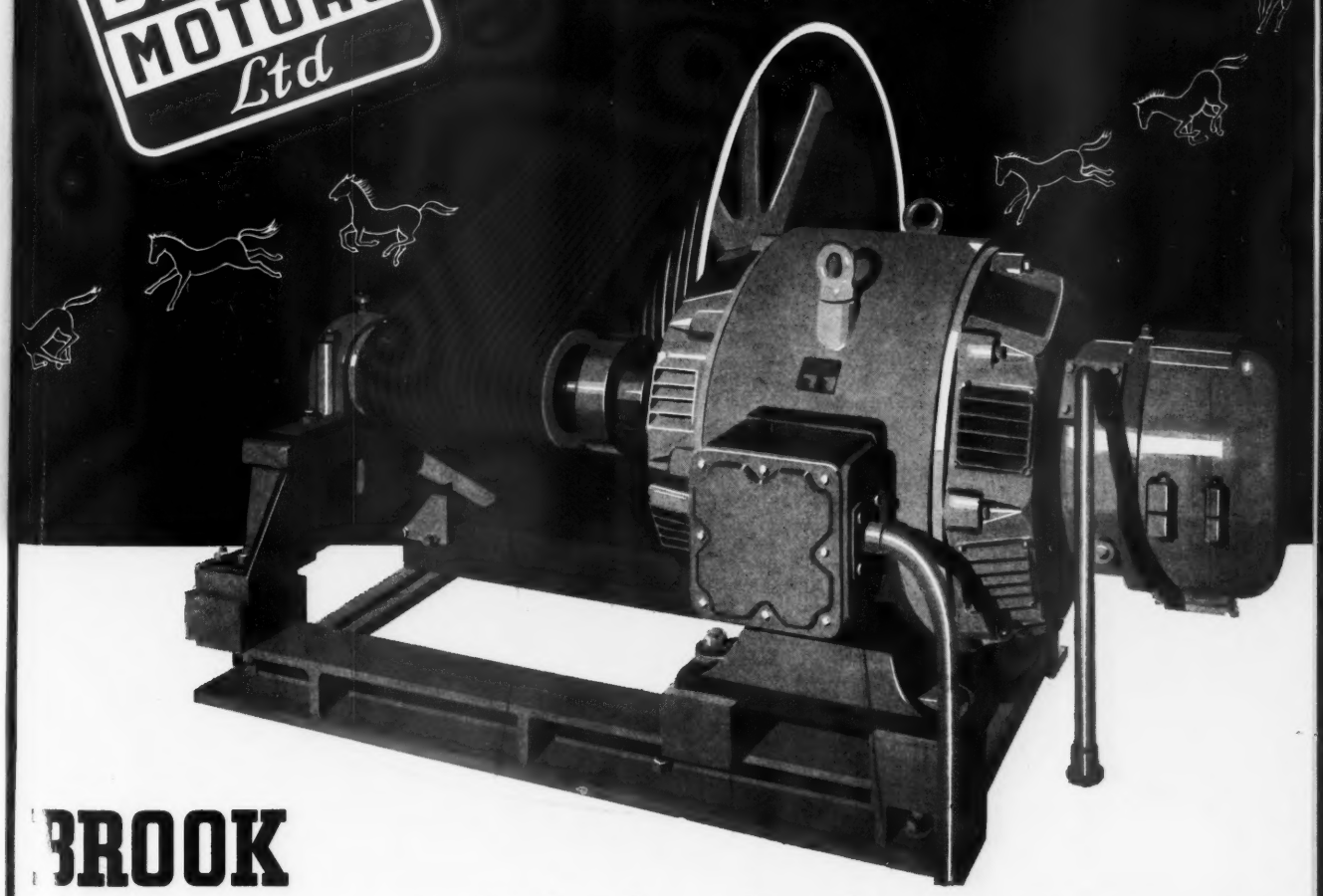

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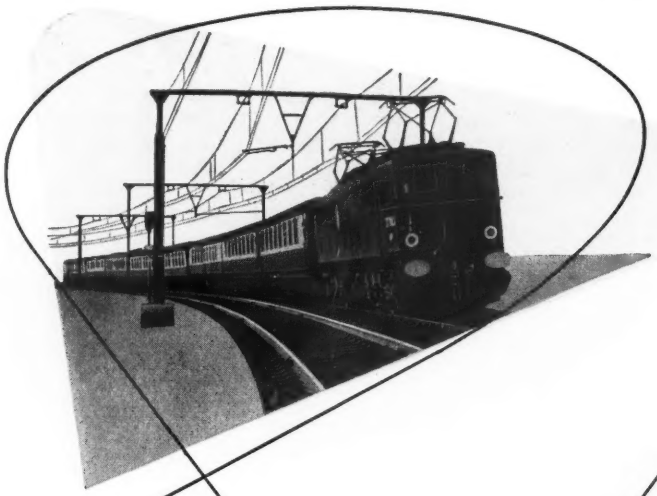

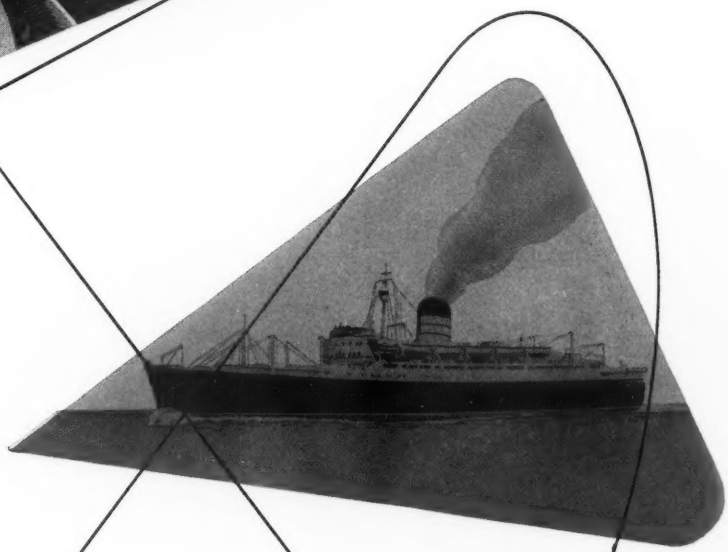

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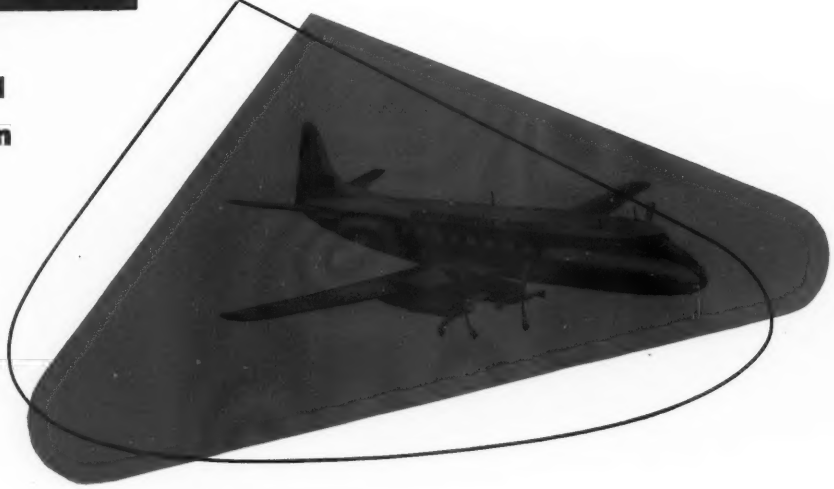

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26 APRIL
1957

ELECTRICAL REVIEW

Managing Editor: HUGH S. POCOCK, M.I.E.E. *General Editor:* J. H. COSENS *Technical Editor:* P. W. TUCKER, M.I.E.E.

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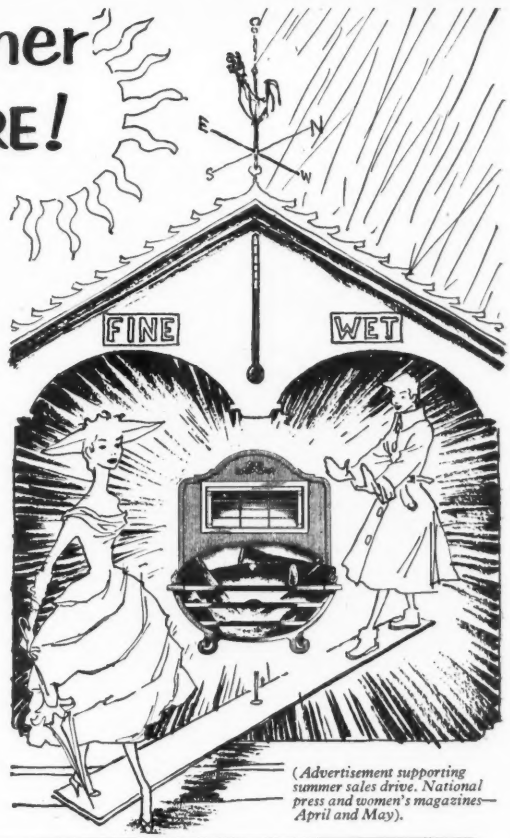

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ELECTRICAL REVIEW

26 April 1957 Vol. 160 No. 17 Established 1872

European Free Trade

MUCH confusion exists in current discussions on the various aspects of European integration and that is not to be wondered at. Since the end of the last war there have been a number of arrangements between various countries of Europe, beginning with "Benelux" and the Organisation for European Economic Co-operation, but so far as we know there has been no comprehensive publication explaining these arrangements. Now there has appeared a valuable booklet from the Federation of British Industries, based on the French text of the Treaty for the European Economic Community signed in Rome last month, which deals mainly with European free trade but also summarises the other agreements arrived at by European countries.*

It is very useful to have the terms "customs union," "common market" and "free trade area" defined, for it is here that most misunderstanding exists. This country is committed in principle to the European free trade area in which there will be no tariffs as between the countries taking part, although their individual and often different tariffs (including any tariff preferences) *vis-à-vis* the rest of the world will remain unaffected.

The common market treaty arrived at by the "Six"—France, Western Germany, Italy, Belgium, Holland and Luxembourg—provides for a common tariff against the rest of the world. If the United Kingdom does not participate in the free trade area, goods exported to the Six will have to face this common tariff; if we do participate we shall be better placed in the European market than outside competitors. Competition between the countries of the free trade area would have to be on an equal footing; for this reason (as was stressed in the 1956–57 B.E.A.M.A. report) a number of rules would have to be formulated and adhered to. In fact such rules are already embodied in the common market agreement of the Six.

Apprehension of the possible effects upon the British electrical industry was expressed in the before-mentioned B.E.A.M.A. report where it was shown in some detail how many points had to be considered. Under existing arrangements the industry is able to export to the six countries twice as much as they export to Great Britain. It is feared that free trade would undermine the industry's basic home market; strengthen the competitive capacity in our Commonwealth markets of the United States and Russia; and probably free productive capacity in other member-countries to attack the United Kingdom and Commonwealth markets.

In the recent White Paper on the subject (Cmd. 72) the Government recognised the existence of disparities in several regulations which were "likely to distort the free play of competition" and considered that they should be corrected at the beginning of the transitional period (minimum twelve years). There were other factors which it was

* "European Free Trade Area: A Survey for Industrialists." Federation of British Industries, 21, Tothill Street, London, S.W.1. Price 6s.

thought did not call for previous rectification, and yet some of them are very significant. It is clear that as the Government has decided that Great Britain must participate in a European free trade plan, the industry has to accept the position. But before we become fully involved the Government should be quite sure that the rules to secure fair competition are adequate and enforceable.

PROGRESS IN NUCLEAR POWER

This country is engaging in a very large programme of nuclear power station construction and development. It all began with Calder Hall which was commissioned only six months ago and at that time appeared to be a plant of very advanced design. However, a great deal was learnt during the design and construction of this station and, as a result, the industrial groups have prepared designs which are considerably in advance of the first atomic power station. On the opposite page we present a comprehensive article describing one of the first commercial stations with a specially-prepared drawing. It has been designed and is to be constructed for the South of Scotland Electricity Board by the G.E.C.-Simon-Carves Atomic Energy Group. This station will provide further justification for this country's choice of the graphite-moderated gas-cooled reactor and although the plant represents a considerable improvement upon Calder Hall, there is no doubt that even further advances will be made in the future.

POWER RECTIFIER COMPARISON

A valuable feature of the article by Mr. M. H. Tovey on "Power Rectifiers" on page 779 of this issue is the survey of the design and duties of the different types of rectifiers now available, from the earlier mercury-arc rectifier to the more recently developed semi-conductor equipment, which indicates fairly definitely their respective fields of application.

That the rate of development work in this field is likely to be accelerated is shown by the author, particularly in his concluding remarks in which he comments on the fact that although the germanium transistor has at present reached only low current proportions its development to the point at which it can deal with power loads can be expected; this will permit limited voltage control without additional apparatus and thus bring it into line with the mercury-arc rectifier. Further, as the author points out, there may be even greater developments in connection with the silicon rectifier in view of its ability to operate in higher ambient temperatures than germanium can.

FAULT ANALYSIS

"The design, construction and operation branches of public or private supply can learn much from the objective analysis of system defects" say Messrs. Jesty and Stewart in their article "Fault Classification and Analysis" which appears on page 770 of this issue. This is certainly evident from the impressive range of illustrations which they have used in the article if not, at first, to the same extent from the mathematics which they have used to expound their methods.

It is certainly logical, as they say, to distinguish between faults which cause interruptions of supply or operations of relays or fuses, and defective system conditions which, if allowed to persist, might cause interruptions of supply or operations of relays or fuses. We can hardly agree, however, that defective system conditions, because they are most often brought to light by routine inspection, should be excluded from any fault analysis. One might as well say that routine inspections should be extended and be so thorough as to detect all fault conditions in time for them to be corrected before supply interruptions can occur. As this ideal cannot be achieved in an imperfect world a better balance will be obtained by the fuller analysis.

RESTRICTIVE PRACTICES

Mr. R. L. Sich, the Registrar of Restrictive Trading Agreements, said last week that of 1,400 agreements filed about 1,000 had been cleared for registration by 15th April. He anticipated a number of "legal battles" when some of the agreements went before the Restrictive Practices Court. The *Manchester Guardian* reports Mr. Sich as saying:—"Those industries which attach great importance to their agreements will fight. The heavy electrical industry, for instance, will be one of them."

There is too easy acceptance of the idea that trading agreements must necessarily be wrong. The B.E.A.M.A. Council said in its 1956-57 report the industry considered that "the criteria for assessing the public interest as defined in the Act under Clause 21 (1) are so narrowly drawn that it will be exceedingly difficult to justify a practice despite the fact that it may have real advantages in the public interest." The Council went on to suggest that the abolition of some general practices might not only disrupt the smooth working of the industry concerned but in the case of the electrical industry might have repercussions on every other section of industry and its export trade.

OFFER FOR BRUSH GROUP

The chequered history of the Brush Group has reached an entirely new point with the offer by Hawker, Siddeley for the whole of the group's issued capital (£22 million). At the date of the offer the terms were such as to give holders of Brush ordinary shares a small margin on the exchange. Hawker, Siddeley's offer apparently arises from their desire to extend their range and particular reference has been made to nuclear power possibilities; they recently formed the Hawker, Siddeley Nuclear Power Co.

The announcement of the offer coincided with a statement by the Brush Group that it was acquiring Asea Electric, Ltd., the English subsidiary of the Swedish A.S.E.A., who supply a wide range of electrical equipment.

Next week's issue will devote special attention to export trade. In addition to articles on the subject there will be a world map showing in colour the principal markets and the proportion of the trade enjoyed by the leading exporting countries. There will also be a preview of the electrical exhibits at the British Industries Fair, Birmingham

South of Scotland Nuclear Power Station

DESIGN FOR 320 MW BASE LOAD STATION

IN December, 1956, the South of Scotland Electricity Board placed a contract for a 320 MW nuclear generating station with the G.E.C.—Simon-Carves Atomic Energy Group. Comprehensive design data relating to this plant are now available and although the site has not yet finally been fixed, permission is sought for its erection on the Ayrshire coast at Hunterston. It is anticipated that work will begin very shortly and the first reactor is scheduled to become critical in 1960. The second reactor should follow suit about six months later.

Essentially, the station is similar to the Calder Hall installation, but it is larger and incorporates many refinements in design which should result in a much higher operational efficiency. As shown in our inset illustration there are two graphite-moderated gas-cooled nuclear reactors, each of which is associated with a group of eight steam raising units feeding three 60 MW turbo-alternators.

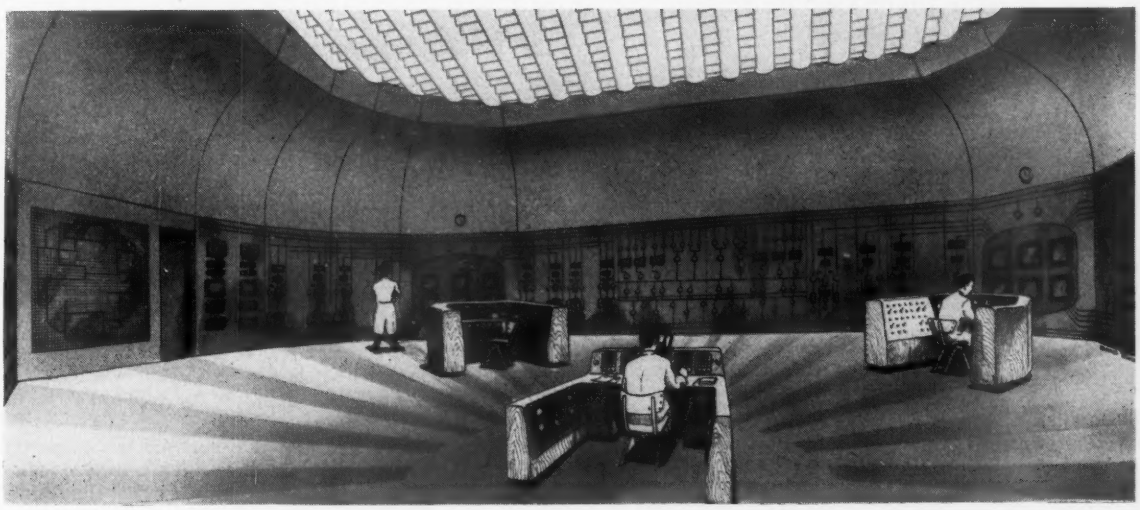
The main difference between this station and Calder Hall is that it does not have to shut down for charging and discharging the reactor with its natural uranium fuel. These operations are carried out while the reactor is on load by means of a remotely controlled charge/discharge machine situated beneath the spherical reactor pressure vessel; the control rods are operated separately from above the reactor. It will thus be possible to operate the plant as a base load generating station with the same degree of availability as is expected from a conventional "fossil" fuel fired station.

The six turbo-alternators together with their associated condensing and feed heating plant are housed in a building separate from the two reactor structures. A double pressure steam cycle has been adopted for the turbines; the pressures and temperatures employed are 585 lb/sq in at 700 deg F and 155 lb/sq in at 670 deg F, respectively, at the high- and low-pressure superheater outlets. Each reactor system with its steam raising units, three turbo-alternators, ancillaries and steam dumping equipment can be operated as a single unit, but provision is made for interconnecting the steam and feed ranges of the two units. A comprehensive system of control and instrumentation is provided in a central control room situated in the turbine hall.

The heart of a nuclear generating station is the reactor and in the present design the 2,000 ton core structure is built up of accurately machined graphite bricks and tiles to form a cylinder 50ft 6in in diameter and 28ft high. The central portion of this structure is the core proper containing the fuel and control rod channels; the remainder acts as a reflector to reduce neutron leakage. The reflector has an average thickness of 3ft at the sides and 2ft 6in at the top and bottom. In the core there are 3,288 vertical fuel channels arranged in the form of a square lattice with a pitch of 8¼in. These are subdivided into groups, in the centre of each of which is a further channel for a control rod.

There is a limit to the amount of heat which can be extracted from a fuel element and this is governed by the heat transfer characteristics of the canning material,

Artist's impression of the central control room of the South of Scotland nuclear power station



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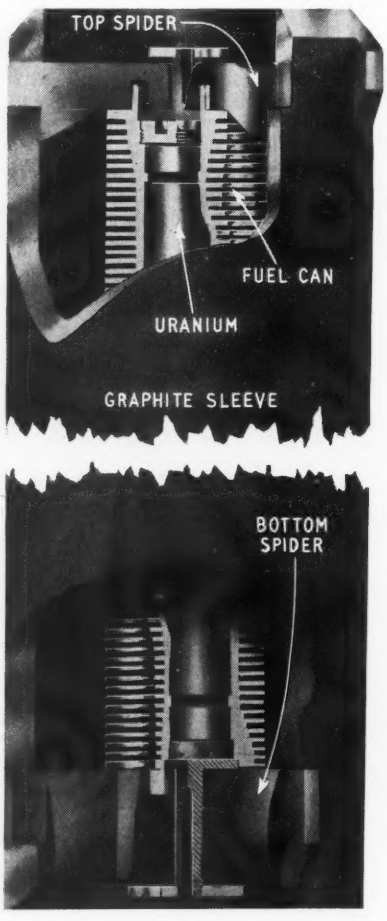
and by the flow of coolant. To increase the total heat output of the reactor without overheating the central channels, the neutron flux distribution (which directly governs the local heat output) is " flattened " so that as many channels as possible operate at the maximum heat rating.

The flattening is carried out by inserting neutron-absorbing stainless steel rods into a number of the central core channels; the flattening rods provide an artificial wastage of neutrons equal to the geometrical leakage in the outer portion of the core. As the fuel is burned up during operation the absorbing material is gradually removed and the flattening is finally achieved by using depleted uranium in the centre of the core. In this way a higher burn-up of the central fuel elements is attained. The maximum neutron flux in this region is about $2{\cdot}5 \times 10^{13}$ neutrons/cm^2/sec. Arrangements are made to ensure that the temperature of the fuel elements in the outer channels, and therefore the temperature of the outlet gas from those channels, is maintained at the same level as that in the centre of the core where the level of reactivity is higher.

The reactor fuel is natural uranium containing 0·7 per cent of fissile U235 and each fuel element is in the form of a cylindrical rod of 1·15in diameter and 24in long, weighing nearly 17 lb. The fuel cans are of magnesium alloy with extended surfaces in the form of fins. Ten fuel elements constitute the complete charge for one vertical channel. For ease of charge and discharge operations it is desirable that they should be placed one on top of the other in the channel. On the other hand, this method imposes considerable stress on the lower elements in the channel because of the weight of uranium, and may lead to distortion by bowing.



The G.E.C. replaceable channel fuel element

Fuel Element Design

The G.E.C. system of fuel element support goes a long way towards meeting these conflicting considerations. The essential feature of the design is that each canned fuel element is individually supported and located by non-metallic " spiders " inside a relatively large bore graphite tube.

The assembled fuel elements, each consisting of a fuel cartridge and a graphite sleeve, can be mounted one on the other within the fuel channel to achieve the desired combination of separately supported elements which are at the same time conveniently stacked for charge and discharge. The tubes are located centrally in the main moderator channels by small graphite lugs on the tubes and by a "cup and cone" arrangement of successive tubes.

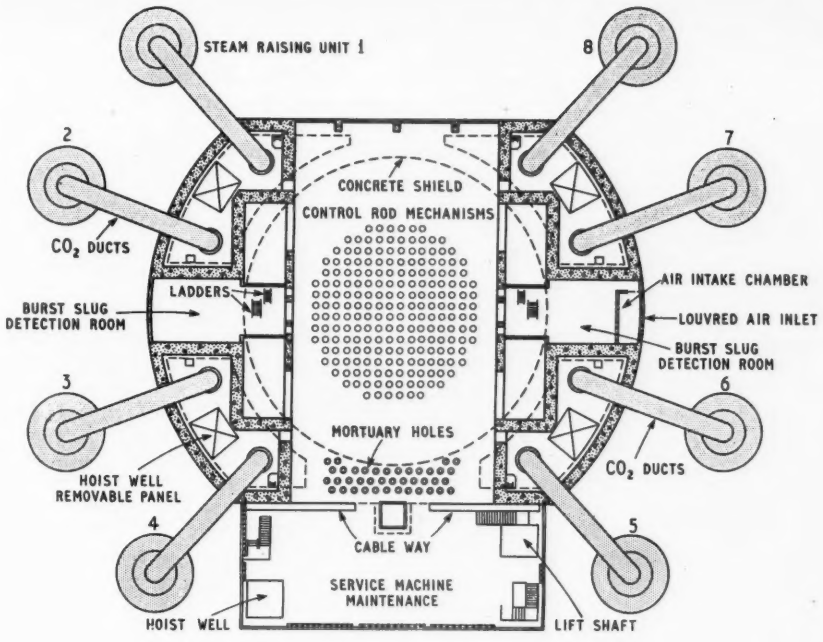
The main gas flow is up through the bore of the graphite tube in direct contact with the fuel elements. A small quantity of gas also passes up the annular space between the graphite sleeve and the main moderator channel to extract the heat, about 6 per cent of the total, generated by collision processes in the graphite itself.

The reactor core rests on support plates on a steel grid which is in turn supported on a steel skirt. The grid is formed of a large number of steel boiler plates some 7ft in depth arranged in " egg-box " fashion with a thick steel top plate, the space between each section being sufficient to accommodate 36 channels of the reactor. On top of the grid structure rests a further series of thick steel plates providing an accurately levelled surface for the erection of the core structure. The core itself is surrounded by an inner cylindrical shell of relatively thin boiler plate, open at its lower end and with a dome at the top. Completely enclosing the core grid and inner shell is a spherical pressure vessel 70ft in diameter. This will be fabricated on site from steel plates 3in thick.

Carbon dioxide at a pressure of 150 lb/sq in is blown into the outer spherical vessel via eight 5ft diameter ducts situated at " equator " level. The cool gas then passes downwards between the outer and inner vessels, and upwards through the support grid and the channels in the graphite core structure. The inner vessel is made of a silicon-killed mild steel boiler plate and has to withstand only the pressure drop across the core of 4 lb/sq in. It is cooled by the incoming gas stream and at its hottest point it will be at a temperature of about 130 deg F below the gas outlet temperature of 745 deg F.

Completely surrounding the reactor is a concrete biological shield. At the base of the reactor the shield is 6ft thick, increasing to a total thickness of 9ft at the sides, while the roof shield is 10ft 6in thick. The 9ft side shield is split into two parts on two arcs between the core and the heat exchangers, yielding " blimps " in which the gas coolant ducts are contained. The inner walls of the blimps are 4ft thick and the outer ones 5ft thick. The shielding is also locally thickened opposite the cold ducts in the inner wall.

As already indicated, the charging and discharging of the reactor are carried out by a single multi-purpose machine working in a shielded chamber below the reactor.



Reactor plan at top shield level

All operations can be carried out under pressure and while the reactor is on load. During charging and discharging the controller observes the movements of the machine on television monitor screens, all movements being remotely controlled from a room in the reactor building.

It will be remembered that the steel grid supporting the core divides the 3,288 fuel channels into "charge groups" of 36 channels each. The channels are continued downwards through the grid by "fixed channel tubes." In any one charge group, the fixed channel tube are bent inwards into gentle curves so that their open lower ends can be fed from a point below the centre of the group.

Vertically below this centre line is a standpipe for each charge group—101 in all. Thus, through each of these 101 standpipes any one of 36 fuel channels in a charge group can be reached by the charge machine. The standpipes project upwards through the spherical shell and downwards to a point just below the biological shield forming the roof of the circular charging chamber. The lower ends of the standpipes are sealed with a steel door protected by a concrete shielding plug.

The charge machine vessel is a cylinder, about 37ft high, which is capable of withstanding the full gas operating pressure. It is seated in a carriage mounted on four wheels. The carriage wheels run on tracks which are in turn mounted on a turntable spanning the diameter of the charging chamber. The turntable runs on two concentric sets of tracks and can rotate through 360 deg. Thus, by rotation of the turntable and movement of the carriage along it, the nozzle in the top of the charge machine can be aligned directly beneath any chosen standpipe.

As indicated in our inset illustration the first operation of the charge machine is to move off the turntable into the loading bay. Above this bay is the charge preparation room where the components of the replaceable channel fuel element are assembled under clean conditions. Five fuel elements, together with a support device and empty graphite tube, are lowered into one tube of a "magazine tube pair" which consists simply of a long open-ended cylinder of polished stainless steel. The empty graphite tube ensures that the lowest fuel element is in the moderator section of the core and not in the surrounding reflector area below. Five more elements are then lowered into another similar tube, the two being strapped together and forming a "magazine tube pair" containing a complete fuel element charge for one channel. The pair of tubes is then guided downwards through a hatch in the charge preparation room floor into the opening in the top of the charge machine.

This process can be repeated if necessary until several pairs of tubes are supported in racks within the machine. The magazine itself has a 1ft thick lead shield. The loaded machine is driven back on to the turntable and the nozzle positioned below the required standpipe.

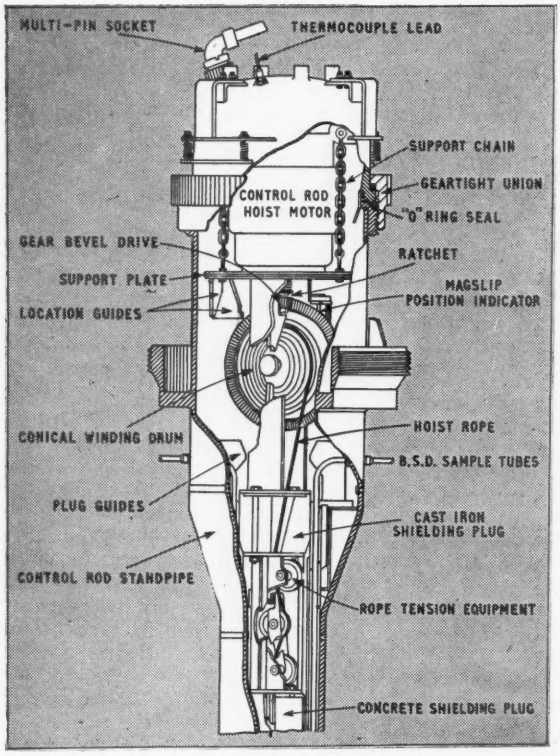
To facilitate precise alignment to within 0·1in two television cameras are mounted at right angles on top of the charge machine. They are focused on to vertical datum lines on the standpipe and the charge machine nozzle, and the position of the machine is adjusted until these coincide on the television monitors in the control room.

The clearance between the top of the charge machine nozzle and the bottom of the standpipes is about 3in and this is taken up by raising the whole machine on four synchronised electrically operated jacks until the surfaces abut. The flanges on the two nozzles are then clamped together over an "O" ring by eight CO_2 operated piston clamps situated radially round the nozzle.

The charge machine is now ready for operation. Under normal reactor running conditions the sequence of operations will be to remove one column of ten fuel elements from a fuel channel and then replace them by ten fresh elements. Both these operations will be carried out with the reactor on load and under pressure, the gas supply to the channel being maintained by a positive displacement channel cooling compressor contained within the charge machine pressure vessel. Discharged radioactive fuel elements are retained within the machine during the recharging process and are later removed for storage in the pond which is situated between the two reactor structures.

Another function of the charge machine is axial inversion. This consists of removing the partially irradiated fuel elements contained in a channel and re-inserting them in a different order so that those elements which have been highly irradiated in the centre of the core are now situated at the ends, and vice versa. This results in the fuel elements in any one channel receiving a much more uniform total irradiation and considerably increases the burn-up of the fuel.

Once a day the charge machine will undergo a series of



Arrangement of control rod mechanism

tests corresponding exactly to the handling of fuel in the reactor, to prove that the many and varied motions of the machine are in proper working order. The test bay is provided with a dummy standpipe end above which is a group of 36 dummy fixed channel tubes at a level corresponding to that inside the reactor. An exit bay from the charge machine chamber enables the machine to be conveyed to the charge machine maintenance building. Three identical machines will be provided for the station so that one can be undergoing planned maintenance while the other two are in operation beneath the reactors.

The irradiated fuel element storage pond is common to both reactors. It is 186ft long, 53ft wide and 18ft deep. At the termination of the conveyor duct from each reactor is a heavily shielded concrete block house, and between the two block houses on opposite sides of the pond is a concrete wall. The pond is thus divided into two unequal sections, the larger for storing normally discharged cartridges and the smaller for cartridges from channels in which a burst has occurred.

The capacity of the cooling pond is such that the complete fuel charge from one reactor can be dumped into it in the event of an emergency, as well as the normal number of cartridges issuing from one running reactor. The fuel elements are stored under water in skips for 120 days after which time the skips are placed in 12in thick iron "coffins" and removed from the site for reprocessing by the U.K. Atomic Energy Authority.

Reactor Control Rods

There are 208 control rod channels in the reactor core, each of which is associated with 16 fuel channels. Access to the control rod channels is obtained through tubes passing upwards from just above the core, through the inner and outer shells, through the upper biological shield, terminating in a set of 208 larger diameter standpipes. Within each standpipe is a control rod mechanism.

The control rod mechanism consists of a flexible stainless steel wire rope wound on a conically shaped drum driven by a low-frequency permanent magnet motor. Each control rod is moved into or out of the core by applying a three-phase low-frequency supply to the motor stator; the rods are held stationary by reducing the supply frequency to zero. The motors are arranged in groups, each group being connected to the same low-frequency supply so that the motors are driven in synchronism. The low-frequency supply equipment is situated outside the biological shield.

The stainless steel wire rope supporting the control rod passes through a small-bore hole in the centre of a long concrete shielding plug which is attached to the control rod mechanism. The control rods themselves consist of a lightweight boron-containing material canned in a thin stainless steel sheath. Short lengths assembled in this way are then placed within the main control rod tube. The completed control rod is 21ft long and 2in in diameter.

The control rods are divided into four groups—two coarse controls, a fine control and a safety group. The two coarse groups are capable of a combined reactivity control of 4·85 per cent, while the fine group controls 0·4 per cent reactivity and the safety group 1·25 per cent. In an emergency the supply to all the control rod motors is cut off and the four groups of rods fall into the core under gravity. The rods initially accelerate until they are well into the core but towards the end of their travel a braking force is applied so that their final velocity is low. This characteristic is governed by the conical shape of the winding drum and the impedance of the closed winding in the stator.

A reactor servicing machine in the form of a travelling pressure vessel is situated above the upper biological shield of the reactor. This enables planned maintenance operations to be carried out on the control rods and control rod mechanisms while the reactor is under load and pressure. The servicing machine can be placed over any one of the 208 upper standpipes by longitudinal and cross-travel motions. Through each standpipe the servicing machine can communicate with one control rod channel and its 16 associated fuel channels.

The control gear and the control console are mounted, together with the pressure vessel, on the crab of the machine. The operator sits at the console and is provided with local shielding to protect him from the gamma activity arising when certain units are removed from the reactor. Use is again made of closed circuit television to supervise the various operations of the machine.

The bottom booms of the main travelling bridge of the machine are provided with trolley beams on which a pair of five-ton travelling electric hoists are mounted. These are used for handling the emergency shut-off valve and distance pipe connecting the standpipe to the servicing machine nozzle, and also as general purpose cranes covering the area of the reactor roof. Apart from its main function in maintaining and replacing the control rods and control rod mechanisms, the reactor servicing machine is designed to carry out a number of other operations of an emergency nature.

As in the Calder Hall reactors, burst slug detection equipment is installed to detect the escape of radioactive fission products due to failure of a fuel element, and to locate the channel containing the faulty element so that the reactor and gas circuit may be safeguarded from the release of fission products.

These functions are performed automatically by

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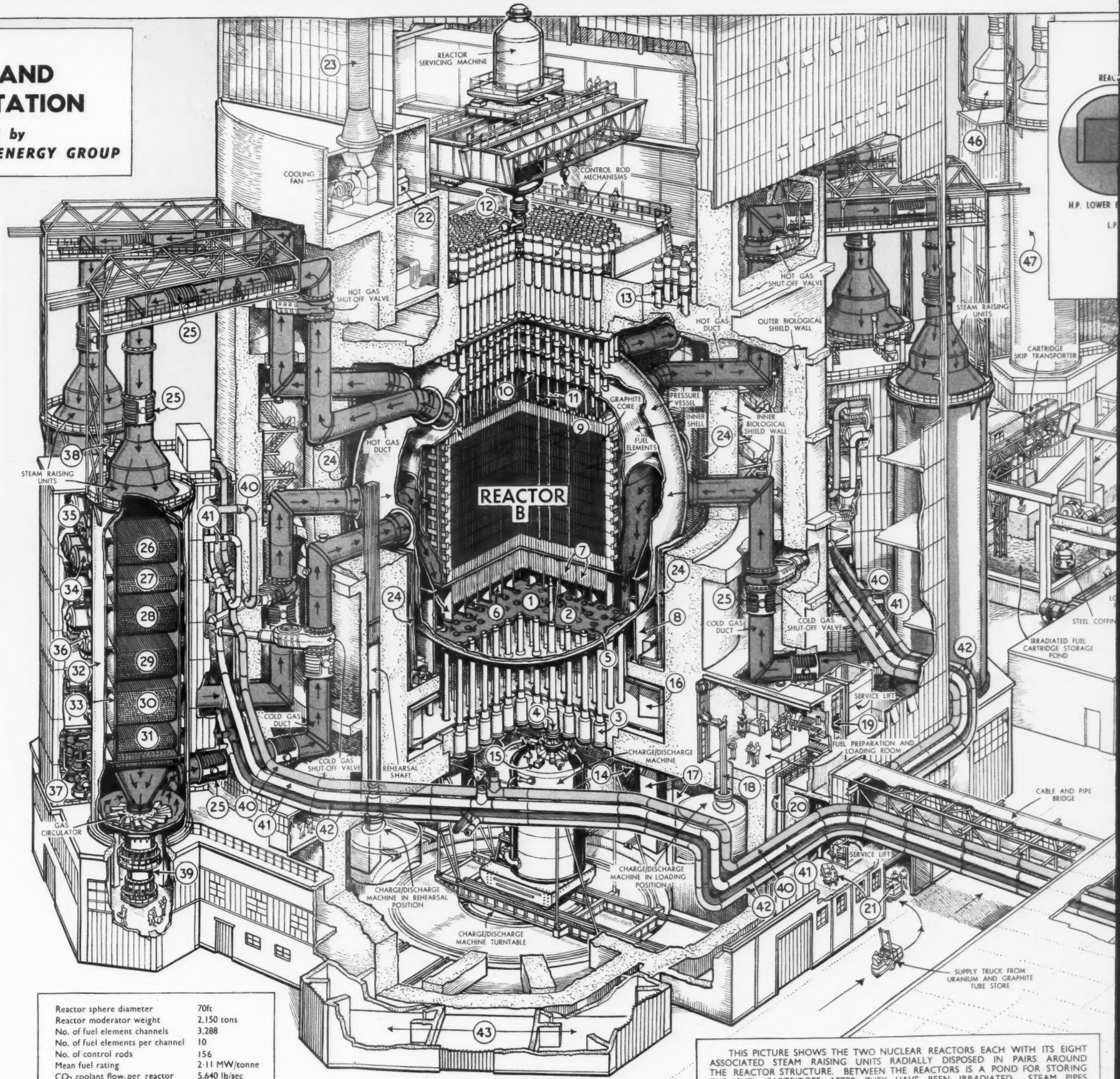
ELECTRICAL REVIEW 26 APRIL 1957

SOUTH OF SCOTLAND NUCLEAR POWER STATION

360 MW Plant Designed by G.E.C. — SIMON-CARVES ATOMIC ENERGY GROUP

THE nuclear generating station which has been designed and is to be erected for the South of Scotland Electricity Board by the G.E.C.—Simon-Carves Atomic Energy Group has a total installed capacity of 360 MW. Essentially, this station is similar to the Calder Hall installation, but it is considerably larger and incorporates many refinements in design which should result in a much higher operational efficiency. There are two graphite moderated gas-cooled nuclear reactors, each of which is associated with a group of eight vertical type steam raising units feeding three 60 MW turbo-alternators. The reactor is arranged for charging and discharging while on load, these operations being carried out by means of a remotely controlled charge/discharge machine situated beneath the reactor pressure vessel. The control rods are operated from above the reactor. The six turbo-alternators together with their associated condensing and feed heating plant are housed in a building separate from the two reactor structures.

A double pressure steam cycle has been adopted for the turbines; the pressures and temperatures employed are 585 lb/sq in at 700 deg F and 155 lb/sq in at 670 deg F respectively in the high and low pressure boilers. Each reactor system with its steam raising units, three turbo-alternators, ancillaries and steam dumping equipment can be operated as a single unit. Provision is made for interconnecting the steam and feed ranges of the two units. A comprehensive system of control and instrumentation for the two reactors and their associated plant is provided in a central control room situated in the turbine hall.



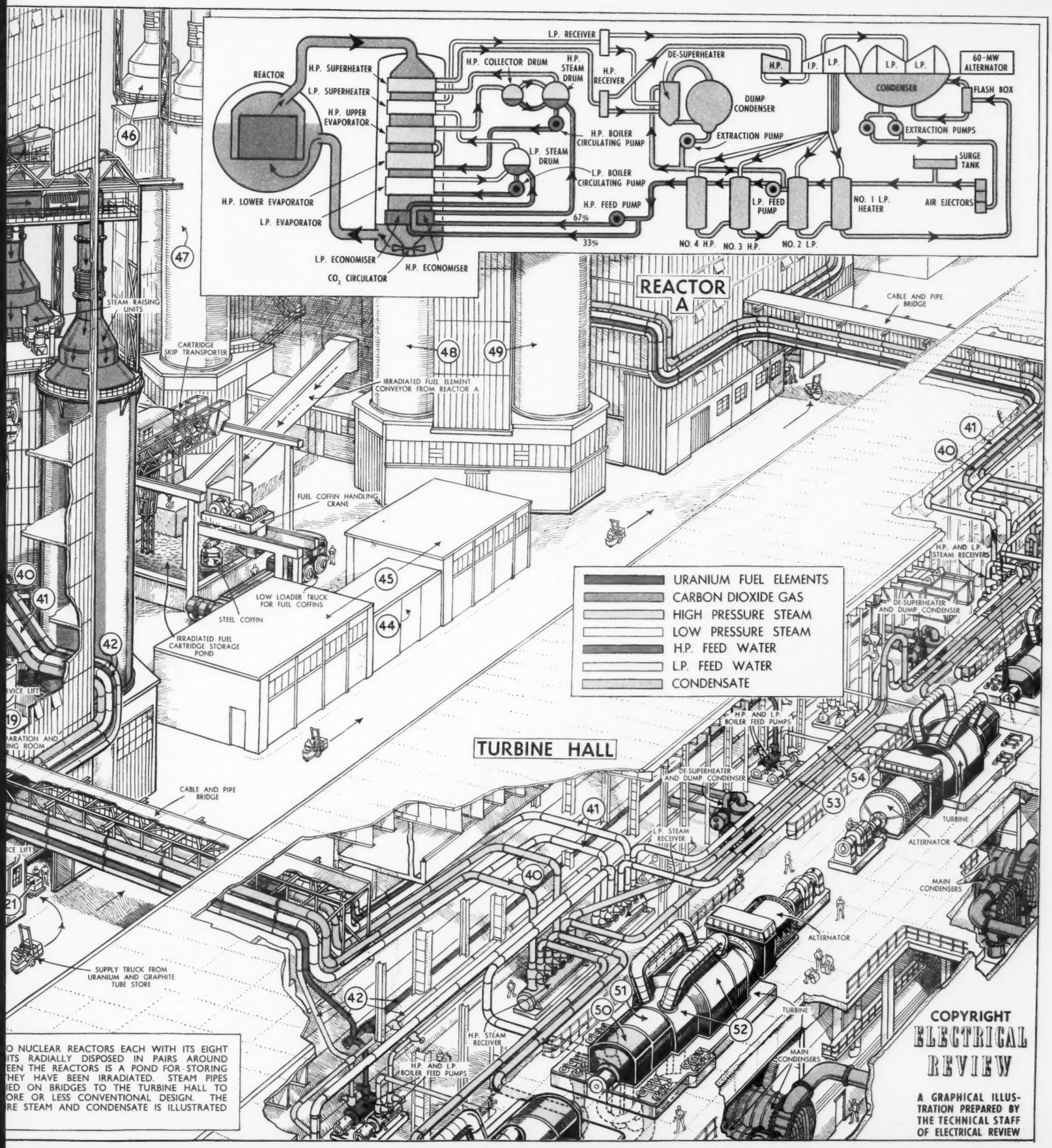
NUMBERED ANNOTATION

1 Fuel charge tube
2 Fuel swivelling chute
3 Standpipe nozzles
4 Charge/discharge machine connected to standpipe
5 Collector pan
6 Core support grid
7 Fixed channel tubes
8 Pressure vessel supporting skirt
9 Control rods
10 Boron sandwich shield
11 Control rod distance tubes
12 Gas shut-off valve
13 Control rod mortuary holes
14 Discharge bay to separating room
15 Television cameras
16 Concrete columns supporting pressure vessel skirt
17 Main concrete columns supporting biological shield
18 Fuel magazine tube guides to charge/discharge machine
19 Vacuum cleaning room
20 Fuel magazine tube store
21 Pallet trolleys
22 Burst slug detection precipitator units
23 Cooling air chimney
24 Biological shield cooling annulus
25 Expansion bellows
26 H.P. superheater
27 L.P. superheater
28, 29 H.P. evaporators
30 L.P. evaporator
31 H.P. and L.P. — I.T. economisers
32 Pressure shell
33 Internal gas casing
34 H.P. collector drum
35 H.P. steam drum
36 L.P. steam drum
37 H.P. and L.P. boiler circulating pumps
38 Safety valve blow-off points
39 Gas circulator motor
40 H.P. steam pipe
41 L.P. steam pipe
42 H.P. and L.P. feed water pipes
43 Steam raising unit sub-structure
44 CO storage annexe
45 CO_2 generator buildings
46, 47, 48, 49 Steam raising units (Reactor A)
50 H.P. cylinder
51 I.P. cylinder
52 L.P. cylinder
53 H.P. steam interconnector
54 L.P. steam interconnector

Reactor sphere diameter	70ft
Reactor moderator weight	2,150 tons
No. of fuel element channels	3,288
No. of fuel elements per channel	10
No. of control rods	156
Mean fuel rating	2·11 MW/tonne
CO_2 coolant flow, per reactor	5,640 lb/sec
Reactor CO_2 inlet pressure	150 lb/sq in
Reactor CO_2 inlet temperature	400 deg F
Reactor CO_2 outlet temperature	745 deg F

THIS PICTURE SHOWS THE TWO NUCLEAR REACTORS EACH WITH ITS EIGHT ASSOCIATED STEAM RAISING UNITS RADIALLY DISPOSED IN PAIRS AROUND THE REACTOR STRUCTURE. BETWEEN THE REACTORS IS A POND FOR STORING THE FUEL CARTRIDGES AFTER THEY HAVE BEEN IRRADIATED. STEAM PIPES FROM THE REACTORS ARE CARRIED ON BRIDGES TO THE TURBINE HALL TO DRIVE TURBO-GENERATORS OF MORE OR LESS CONVENTIONAL DESIGN. THE FLOW OF HIGH AND LOW PRESSURE STEAM AND CONDENSATE IS ILLUSTRATED IN THE FLOW DIAGRAM ABOVE.

MAX MILLAR


L.P. RECEIVER
REACTOR
H.P. SUPERHEATER
L.P. SUPERHEATER
H.P. UPPER EVAPORATOR
H.P. LOWER EVAPORATOR
L.P. EVAPORATOR
H.P. COLLECTOR DRUM
H.P. STEAM DRUM
H.P. RECEIVER
H.P. BOILER CIRCULATING PUMP
L.P. STEAM DRUM
L.P. BOILER CIRCULATING PUMP
H.P. FEED PUMP
67%
33%
L.P. ECONOMISER
CO_2 CIRCULATOR
H.P. ECONOMISER
DE-SUPERHEATER
DUMP CONDENSER
EXTRACTION PUMP
H.P.
I.P.
L.P.
L.P.
L.P.
CONDENSER
60-MW ALTERNATOR
FLASH BOX
EXTRACTION PUMPS
SURGE TANK
L.P. FEED PUMP
NO. 1 L.P. HEATER
AIR EJECTORS
NO. 4 H.P.
NO. 3 H.P.
NO. 2 L.P.
REACTOR A
STEAM RAISING UNITS
CARTRIDGE SKIP TRANSPORTER
IRRADIATED FUEL ELEMENT CONVEYOR FROM REACTOR A
CABLE AND PIPE BRIDGE
FUEL COFFIN HANDLING CRANE
LOW LOADER TRUCK FOR FUEL COFFINS
STEEL COFFIN
IRRADIATED FUEL CARTRIDGE STORAGE POND
H.P. AND L.P. STEAM RECEIVERS
DE-SUPERHEATER AND DUMP CONDENSER
URANIUM FUEL ELEMENTS
CARBON DIOXIDE GAS
HIGH PRESSURE STEAM
LOW PRESSURE STEAM
H.P. FEED WATER
L.P. FEED WATER
CONDENSATE
TURBINE HALL
H.P. AND L.P. BOILER FEED PUMPS
DE-SUPERHEATER AND DUMP CONDENSER
L.P. STEAM RECEIVER
TURBINE
ALTERNATOR
MAIN CONDENSERS
SUPPLY TRUCK FROM URANIUM AND GRAPHITE TUBE STORE
H.P. STEAM RECEIVER
H.P. AND L.P. BOILER FEED PUMPS
O NUCLEAR REACTORS EACH WITH ITS EIGHT
ITS RADIALLY DISPOSED IN PAIRS AROUND
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HEY HAVE BEEN IRRADIATED. STEAM PIPES
IED ON BRIDGES TO THE TURBINE HALL TO
ORE OR LESS CONVENTIONAL DESIGN. THE
RE STEAM AND CONDENSATE IS ILLUSTRATED
COPYRIGHT
ELECTRICAL REVIEW
A GRAPHICAL ILLUSTRATION PREPARED BY THE TECHNICAL STAFF OF ELECTRICAL REVIEW

successive sampling, in groups of four, of the gas from the 3,288 fuel element channels throughout the reactor. Any solid components in the gas are filtered out and the daughter products of gaseous fission products are electrostatically precipitated to give a measure of the extent of a fault in an element. Each filter unit contains a Geiger counter to detect any deposits of uranium oxide. The precipitators are situated in two diametrically opposite rooms on the reactor cap. When the sample test shows a high activity level in a group of four channels, it is possible to operate equipment manually to find the individual faulty channel.

Steam Raising Units

Associated with each reactor are eight heat exchangers designed by Simon-Carves, Ltd., whose function is to remove heat from the circulating gases and use it to raise steam for driving the turbo-alternators. Essentially, each unit consists of two water tube boilers (high pressure and low pressure) contained within a vertical cylindrical pressure shell.

The heat exchanger shell is of welded construction, 19ft 6in diameter internally and 73ft 6in high overall, and will be fabricated and erected by the Motherwell Bridge & Engineering Co., Ltd. It is self-supporting and stands on a cylindrical support and base ring. The complete shell, weighing 210 tons, will be lifted into position by the 300 ton Goliath crane specially designed and built for nuclear power plant construction.

Hot gas leaves the top of the reactor vessel through 5ft diameter ducts and enters the top of the heat exchanger shell at 745 deg F. It then flows downwards across banks of self-draining multi-loop tube elements which form the economiser, evaporator and superheater sections of the boiler. The gas leaves the heat exchanger at 392 deg F and passes through a circulator on its way back to the reactor pressure vessel. Individual tube elements are connected in parallel by headers outside the pressure shell. This allows leaks to be detected without entering the shell and enables individual elements to be replaced without cutting and welding inside the shell.

The elements are supported only at their ends to keep the supporting structure out of the gas stream, the individual finned mild steel tubes forming an element being tied together by welded straps to give the element rigidity. As the parallel tubes are of equal lengths the tube banks occupy a square section within the circular area provided by the shell. The remaining segmental areas are used as a means of vertical access within the shell and are baffled at intervals to prevent by-passing of gas.

All the headers are arranged on one side of the pressure shell and consequently a single structure is used for each pair of units; the drums, headers, pipework, fittings, access platforms and stairways are contained within the space between the units and each pair of units is enclosed in a weatherproof structure.

The quantity of CO_2 circulated through the reactor-heat exchanger system is over 5,000 lb/sec at 150 lb/sq in. Rapid-closing isolating valves are incorporated in the gas circuits at the reactor inlets and outlets; in the event of the failure of a circulator or of any component of a circuit it can be quickly isolated from the rest of the plant for maintenance purposes without shutting down the reactor. A reduced reactor load can then be carried by the units remaining in service.

Important auxiliary items associated with the coolant circuits are by-pass filter circuits to keep down the level of dust formed by possible corrosion or erosion of the plant, by-pass dryer circuits to remove any moisture introduced into the gas by possible slight leaks in the boiler tubes, and the CO_2 storage plant and pipework system for filling the plant at start-up and for making good any losses caused by leakage.

One single-stage centrifugal gas circulator is situated in the base of each heat exchanger, so that it handles the gas at the lowest temperature. The impeller, with backward curving vanes, is mounted on a vertical overhung shaft at the base of the heat exchanger. The pressure shell of the heat exchanger is large enough to accommodate the impeller, the diffuser and an inlet fairing to the eye of the impeller, thus avoiding the need for a special pressure casing.

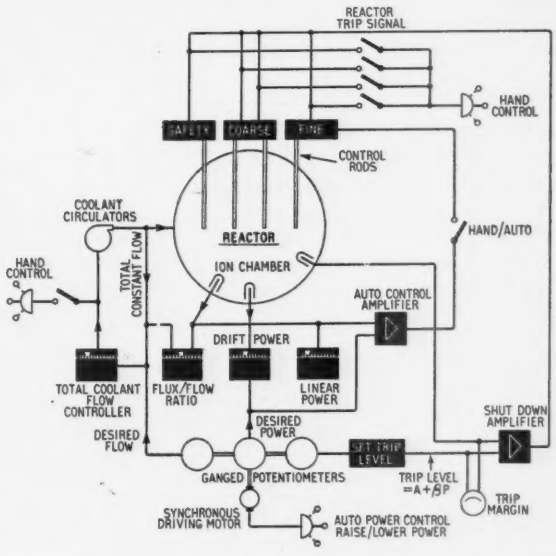
The circulator unit, comprising impeller, shaft, seal, bearings, drive and cooling system, is suspended from a flange on the pressure shell. The drive is a tandem-armature d.c. shunt motor supplied through transformers and twelve-phase steel tank mercury arc rectifiers having grid control by individual phase shifters. The phase shifters may be coupled together to give a ganged control of any number of circulators. Each motor is rated at 2,200 h.p. at 1,000 r.p.m. and is air-cooled, air being forced to the centre of the machine by an external fan and exhausting over the commutators at the ends.

Steam Cycle

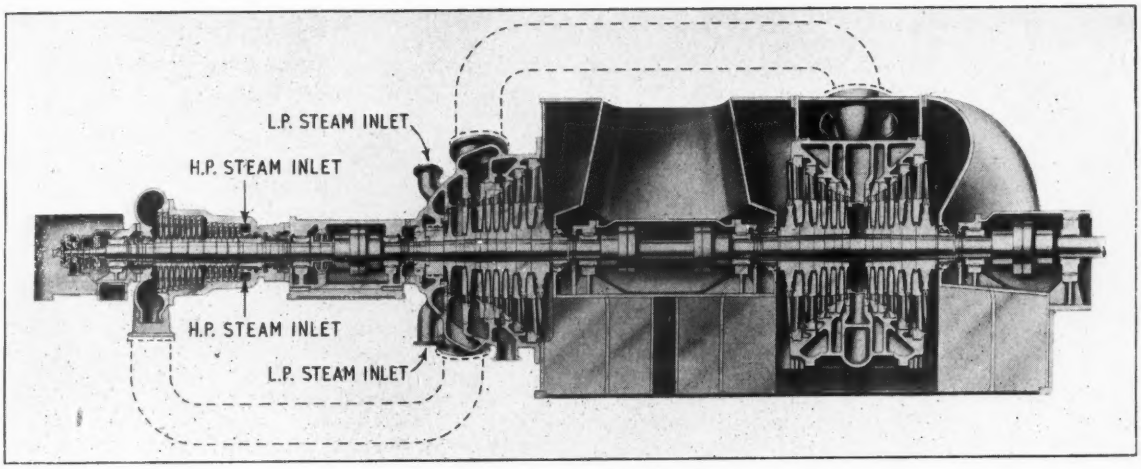
As a dual pressure steam cycle has been adopted the heat exchanger has two independent boiler systems (high pressure and low pressure), each comprising economiser, evaporator and superheater sections. These sections are so arranged in the gas stream that the best use is made of the temperature differences which are available for heat transfer.

The double-pressure boiler is used with a pass-in turbine in which the l.p. steam is admitted to the turbine at an intermediate stage of the expansion. This has the effect of improving the turbine efficiency and the steam dryness at the turbine exhaust and obtaining the advantage associated with the reheat cycle used in fuel-fired plants.

The turbine house is 680ft long and 125ft wide. The turbine hall is 65ft wide between crane rails, and is flanked by annexes containing on the one side steam and feed systems, and on the other side electrical equipment and circulating water culverts. In the centre of the electrical



Basic arrangement of the reactor control system



Section through one of the 60 MW turbines

annexe, at operating floor level, is the main station control room. A bridge between each reactor building and the turbine house provides covered access between the buildings and supports steam and feed pipework.

The runs of pipework required to collect steam from the boilers disposed round the reactors, and pass it to the turbine hall, are necessarily rather long, and care has had to be taken in the layout of the pipework so that it will accommodate thermal expansion, without unnecessarily further increasing its length. Fortunately, steam pressures are moderate, and temperatures below the creep range. The economic value of heat and pressure loss in the pipework is unusually high, so low steam velocities and thick lagging are employed. The steam pipes from adjacent pairs of boilers are teed immediately after the stop valves, and this common lead again teed with the lead from the next pair, so that the output from the four boilers on one side of each reactor passes in a single pipe to a steam receiver in the turbine house basement, to which a similar pipe carrying the output from the four boilers on the other side of the reactor is connected. The h.p. and l.p. steam pipework systems are similar. Hence, each reactor has associated with it one h.p. and one l.p. steam receiver. Provision is made for interconnecting, if necessary, the steam receivers of the two reactors. From each steam receiver, a single pipe passes to each turbo-alternator associated with that reactor, and to the steam dumping equipment.

Generating Plant

Six 60 MW 3,000 r.p.m. turbo-alternators are arranged longitudinally in the turbine hall. The turbines are of the same general design as the modern G.E.C. 60 MW units, and where appropriate make use of new features developed for the company's 120 MW and 200 MW reheat machines. The most important of these is the use of a fabricated steel l.p. turbine exhaust casing with only end support, the necessary longitudinal beams being formed integral with the casing walls. This arrangement gives extreme rigidity of support to the main bearings with an internal l.p. casing carrying the fixed blades free to expand independently of the outer casing, the latter being at vacuum temperature.

The generators are normal G.E.C. 60 MW units cooled by hydrogen at 30 lb/sq in, with direct cooled rotor windings, generating at 11·8 kV and connected to the station busbars through step-up transformers. The main and pilot exciters are driven through reduction gearing from the alternator shaft. The pilot exciter is a homopolar alternator supplying power to a magnetic amplifier automatic voltage regulator.

The turbines accept steam at two different pressures, 560 lb/sq in at 690 deg F and 140 lb/sq in at 660 deg F. The h.p. steam is expanded in the h.p. cylinder of the turbine, and passes to the i.p. cylinder, where it is mixed with the l.p. steam, which is passed in. A small thermodynamic loss occurs on mixing, since the expanded h.p. steam is at a lower temperature than the l.p. steam. To minimise this, and to stabilise the governing of the l.p. steam regulating valves, the l.p. steam is expanded through a single velocity stage before mixing.

Due to the moderate steam conditions, the turbine has to handle a much larger quantity of steam than a turbine of the same rating for conventional duty, and a large l.p. end with large exhaust area is required, particularly since it is desirable to achieve a very low leaving loss. As the wetness at the exhaust is high (12·5 per cent for 28·9in Hg vacuum at design load) triple exhausts are used to reduce the l.p. blade length and tip speed. This consideration largely governs the choice of unit rating.

The turbines are pressure governed, the turbine steam regulating valves being the primary control of steam pressure in the system. They are controlled to maintain nearly constant pressure in the steam main, the control having a slightly rising pressure/load characteristic so that the machines may run stably in parallel. Load sharing between sets is adjusted by manual control of the pressure setting of the valves. The governing gear is similar to that used on pass-out turbines, and no new problems are involved in its design.

Generated output is varied by controlling the reactor heat output, the gas circulators and turbo-alternators automatically following. The turbines are also fitted with normal speed control gear for running up and for limitation of overspeeding.

When the sets are on load they accept all the steam generated by the boilers and their speed is controlled only by system frequency. This is acceptable where a sufficient number of conventional speed-controlled sets are connected to the system to stabilise its frequency. It is expected that it will ultimately be convenient, when operating experience has been gained, to operate the sets speed-controlled on load, so that the station can play its part in controlling system frequency; provision has been made to permit this initially.

The three turbo-alternators associated with each reactor

operate into common feed ranges, and the feed ranges of the two reactors are normally interconnected. Feed to the boilers is provided at two pressures, one for l.p. boilers and one for h.p. boilers, and at the same final feed temperature of 296 deg F, obtained by conventional bled-steam feed heating. All the feed is passed through the l.p. feed pumps and the h.p. feed heaters, into the l.p. feed delivery main, which also acts as a suction main for the h.p. feed pumps. Since the feed is required at only moderate temperatures and pressures, no special problems are encountered in the pump design or in the feed system.

In order to dissipate the heat evolved by the reactors when starting up and for a considerable time after shut-down, it is necessary to maintain a small flow of coolant gas through them. To dispose of the steam thus generated in the boilers two steam dumping equipments are provided, each of which can be used with either reactor. Each equipment comprises h.p. and l.p. steam pressure regulating valves, a spray de-superheater fed with condensate, and a surface condenser operating at atmospheric pressure.

The steam pressure regulating valves are similar to those fitted to the main turbines and control the steam pressures in the system under shut-down conditions, with manual setting control, thus giving control over the coolant gas temperature.

The design of the dump condensers, and the passing of condensate to the de-superheating sprays, provides efficient regeneration and de-aeration of the condensate down to very small steam flows, the condensate temperature at exit being about 212 deg F. The condensate passes to the l.p. feed pump suction main, no further feed heating being provided.

Under shut-down conditions it is not convenient or economic to run the main feed pumps, and auxiliary electrically driven h.p. and l.p. feed pumps of small capacity are provided. These and the dump condenser auxiliaries are supplied from the house diesel generators in the event of failure of the normal station auxiliary supply.

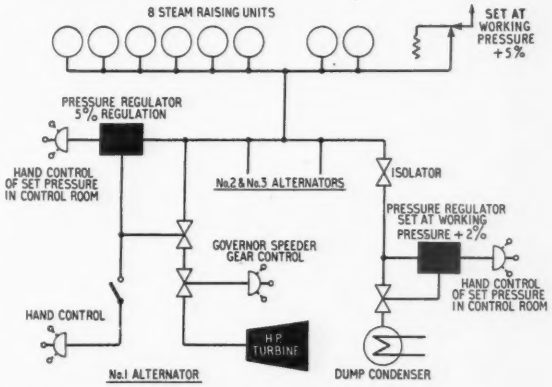
Control and Instrumentation

A comprehensive system of manual controls and appropriate instrumentation for the two reactors and their associated plant is provided in a central control room situated in the turbine building. This ensures that under normal and all except certain extreme emergency conditions complete control over the reactors and steam raising units, and adequate control over all other significant items of plant, is vested in the central control room. A turbine gauge panel is placed close to each turbine, and instrumentation is included in the central control room to afford supervision of the running turbines.

The station load is set by the power generated in the reactors, and all deliberate changes are initiated at one or both reactors. Certain automatic features are incorporated in the control system of each reactor unit to simplify the adjustment of power level and perform stabilising functions; manual over-ride is provided. Essentially, the method of overall control between 25 and 100 per cent of full power involves co-ordinated variation of the neutron flux density, the coolant gas flow and the steam flow. Two separate closed loop circuits are incorporated, one for stabilisation of reactor power operating on four fine control rods, and the other for stabilisation of the total coolant gas flow operating on the circulators. These are termed respectively the automatic flux regulator and the automatic flow regulator.

The two circuits are combined to the extent that settings of desired neutron flux and desired coolant flow are coupled in a single control known as the automatic power control which is motorised (to limit the rate of change of power) and set by the reactor operator at his control desk. A constant ratio is maintained between desired neutron flux and desired coolant gas flow (subject to manual trim). With this system, there is only a small variation with power level of temperatures in the coolant circuits.

The automatic flux regulator adjusts reactivity to compensate for xenon poison transients following deliberate changes in power level, and also maintains a stable power level during "on-load" maintenance operations, such as replacement of control rods, which affect the net reactivity. The automatic flow regulator maintains the desired value of total coolant flow in the event of failure of one circulator by temporarily over-speeding the remaining circulators.


8 STEAM RAISING UNITS
SET AT WORKING PRESSURE +5%
PRESSURE REGULATOR 5% REGULATION
HAND CONTROL OF SET PRESSURE IN CONTROL ROOM
No.2 & No.3 ALTERNATORS
ISOLATOR
PRESSURE REGULATOR SET AT WORKING PRESSURE + 2%
GOVERNOR SPEEDER GEAR CONTROL
HAND CONTROL OF SET PRESSURE IN CONTROL ROOM
HAND CONTROL
H.P. TURBINE
No.1 ALTERNATOR
DUMP CONDENSER

Schematic diagram of control system for h.p. turbine. There is an identical system for l.p. steam

When the operator adjusts the desired power by means of the automatic power control the resultant changed flow of coolant results in a change in heat flow in the steam raising units. Steam pressures are thus affected, and pressure regulators associated with the inlet valves to each turbine automatically adjust the steam flow to maintain constant pressure conditions. Each steam raising unit has a simple form of automatic feed water control operating from drum level.

It is estimated that a power reduction from 100 per cent to 33⅓ per cent full power is capable of being almost entirely carried out in a controlled manner in under 30 min by means of the automatic features provided. As excess steam is blown off in the event of one or more turbo-generators tripping out, rapid decrease of power without having recourse to reactor shut-down is obviously desirable to avoid excessive loss of feed water.

Each turbine is fitted with a governor speed control but in operation this is normally over-ridden by the pressure regulator. The usual emergency overspeed trip is provided. Despite the adequate information available to the control staff, abnormal conditions may not be noticed immediately and a large number of alarms, both aural and visual, urgent and not-so-urgent, are therefore incorporated.

Readers who require additional copies of this issue of the *Electrical Review* are advised to order them without delay, as it is anticipated that there will be a considerable demand for the limited quantity available

NEW BOOKS

Electrical Testing and Trouble Shooting. By Philip T. Green. Pp. 191; figs. The Industrial Press, New York, 13. Bailey Bros. & Swinfen, Ltd., 46, St. Giles High Street, London, W.C.2. Price 34s.

When trouble occurs in a complex electrical circuit its source may be found either by haphazard or by systematic methods. In a useful book, intended primarily for the practising maintenance engineer or technician, Mr. Green explains clearly how system should be put into fault finding. The first step is to have available for all apparatus an easy to understand elementary (i.e. schematic) diagram. Many of us must, at some time or other, have poured invective on those manufacturers, and their name is legion, who provide in their complex equipment only a wiring diagram, which invites a haphazard approach to trouble shooting.

From this beginning a logical system of circuit analysis is developed, with every step simply explained, such that if the advice given is well taken the person or organisation so prepared should find and cure faults much more speedily.

The exact mode of operation, and limitations of, insulation testers, inductive kick tests, cable fault testers, etc., are dealt with in a lucid manner, and lengthy chapters cover the possibilities for peculiar behaviour inherent in d.c. machines, transformers, and the more common a.c. rotating machines. A section deals with bearing troubles.

The book should prove useful to maintenance staff both in industrial plants and in the power supply industry; and although written in American style it is easily understandable in terms of English practice.—H.R.M.

An Introduction to Electrostatic Precipitation in Theory and Practice. By H. E. Rose, D.Sc.(Eng.), Ph.D., M.I.Mech.E., A.M.I.C.E., and A. J. Wood, M.A.Sc., B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E. Pp. 166; figs. Constable & Co., Ltd., 10, Orange Street, London, W.C.2. Price 17s 6d.

This book is a very detailed survey of a subject on which there is limited published information in a comprehensive form. It is the work of a mechanical engineer and an electrical engineer who by research and experiment have sifted out the mathematics of the theory and of practical design so as to give a good picture of efficiency of electrostatic precipitation on its various bases. The book will be of great value to plant designers and the operators of plant who wish to obtain a clearer insight into the peculiarities of the behaviour of charged particles. It is impossible to deal with the theory of precipitation without mathematics, but even if the mathematics used are taken for granted, the engineer reader would gain much knowledge of the subject.

The greatest use of electrostatic precipitation, at least on a weight-extracted basis, is undoubtedly for the extraction of fly ash from pulverised-fuel-fired boilers in power stations. The term efficiency, however, needs to be clarified, since for a given concentration on a weight basis a suspension of fine particles is more opaque than a suspension of coarse material. These very practical points are covered very logically and clearly by the authors, who deal with this practical aspect after covering at length the efficiency from a theoretical viewpoint.

There are chapters on precipitator problems, precipitator design and construction, and the power supply equipment which cover these aspects very widely, but it is felt that they have been dealt with academically, with help from manufacturers, and not so much from users' experience.

A possible omission from this excellent study of the subject is the question of practical tests of efficiency with details of the range of dust sampling equipment which is in use. As the authors point out in their conclusion, there are great possibilities for the improvement of the performance of precipitators, therefore the accuracy of dust sampling equipment is of prime importance in measuring these experiments, particularly as the optimum efficiency is approached.

The publication of this work is very timely in view of the increasing demand for precipitators which will undoubtedly arise from the Clean Air Act, 1956.—F.B.

Vacuum-Tube Circuits and Transistors. By L. B. Arguimbau. Pp. 646; figs. John Wiley & Sons, Inc., New York. Chapman & Hall, Ltd., 37, Essex Street, London, W.C.2. Price 82s.

This volume is a second edition of "Vacuum-Tube Circuits" with the addition of two chapters, comprising roughly 100 pages, on transistor principles and circuits by R. B. Adler.

The earlier book gave a very well-balanced survey of both radio and pulsed techniques, written perhaps more from the viewpoint of a physicist than an engineer, the emphasis being on the underlying principles used in circuit design rather than on the details of actual designs. This very desirable condition has been retained and, in spite of the very modest evaluation made by the authors of the life of their book, will make it useful long after many similar books are out of date.

The new chapters are well done, within the limits imposed by the non-utilisation of quantum methods, limits which are, however, explicitly recognised by the authors. Naturally, this does not detract from the value of the material on transistor circuits. The rest of the book has needed little revision, some short sections such as that on colour television have been added, and some unsatisfactory treatments, such as that of tuned coupled circuits, have been tidied up. The only important criticism to be made is that the chapter on transit time effects is obsolete and should have been revised.

It should be mentioned that the authors do not pretend to include sufficient material on physical electronics, the reader being told to look elsewhere for this.

This is a good workmanlike book, which makes no exaggerated claims and gives plenty of references for supplementary reading. It is heartily to be recommended.—A.H.W.B.

Books Received

Handbook for Welding Design. Vol. 1. General editor, C. Rowland Harman, B.Sc.(Eng.), M.Inst.W. Pp. 305; figs. Published by Sir Isaac Pitman & Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2, for the Institute of Welding. Price 45s.

Power System Communications. Edited by E. Openshaw Taylor, B.Sc., A.C.G.I., D.I.C., M.I.E.E. Pp. 304; figs. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 35s.

Gear Hobbing and Shaving. By A. Sykes, B.Sc., Wh.Ex., M.I.Mech.E., M.I.P.E., M.S.A.E. Pp. 90; figs. David Brown Industries, Ltd., Meltham, nr. Huddersfield, Yorkshire. Price 25s.

Les Redresseurs de Courant dans l'Industrie. By J. Lecorgeiller. Pp. 158; figs. Editions Eyrolles, 61, Boulevard Saint-Germain, Paris, Ve, France. Price 1,850 francs.

VIEWS on the NEWS

By REFLECTOR

NECESSITY, arising from the uncertainty of our fuel supplies, has forced us to go ahead with the development of nuclear power with the best means we have at present —the water-cooled graphite-moderated reactor. The Americans, being under no such compulsion, are still experimenting with a number of types of reactors and admit that they are behind us in the securing of practical results. At a nuclear engineering conference last month in Philadelphia one delegate said that while the Americans' programme was adequate to cope with their eventual domestic needs it was inadequate to meet immediate opportunities in foreign countries. He thought that the reason was that they had no natural uranium type reactors in development. According to the *Electrical World*, he went on to say that this was the type which "enrichment poor" nations favoured and because of this England will get as big a share of the foreign market as its industrial capacity will permit. Another speaker urged concentration on one type of reactor, citing the British decision to build and improve the Calder Hall type.

* * *

Langstrothdale in Yorkshire is the subject of the latest protest against overhead transmission and letters on the matter have appeared in the *Yorkshire Post*. One correspondent suggests that if a little economy was exercised by the Electricity Board the extra cost of underground cables could be met. She suggests, for instance, that

> "Consumers of electricity who can afford them will certainly buy such things as washers, cookers, cleaners and all the other gadgets, even if not displayed in the expensively palatial show places so often seen."

Having put forward this view, which ignores elementary commercial principles, she goes on to suggest that perhaps a fund could be opened to make up the extra cost of underground cables and says "Possibly the C.P.R.E. might be able to help in organising this." It would certainly be a practical way for the Council to demonstrate its solicitude for the countryside.

Another correspondent thinks that the National Parks Commission might devote some of its funds to this purpose.

* * *

I suppose that it is not usual for a hydro-electric turbine to shed a wheel and continue to operate. The Uganda Electricity Board had this experience eight or nine years ago and now that it has recovered the runner tells the whole story. The set is, of course, only a small one (about 750 kW); it is installed at Kikagati on the Kagera River. There were three runners on the shaft and when one of them fell off into the river through the draft tube it could not be immediately recovered and the turbine remained running at about half its capacity. Recently it was decided to try to recover the runner and test prods located it buried in about ten feet of mud and silt above which there was nine feet of water. The silt was pumped away and Mr. I. H. Wilson, a civil engineering contractor, went down the draft tube in a diving suit and succeeded in attaching a wire rope to the runner which was brought to the surface and, after cleaning, found to be in good condition. It is now being (or has been) restored to its original position.

* * *

In the atomic power world the term "Calder Hall" has become the accepted description of the graphite-moderated natural-uranium type of nuclear reactor—even in the United States. But it goes further than this as a way of referring to a prototype. A recent note in the *Observer* on State encouragement of the theatre included the remark that

> "the Government should announce that construction of the National Theatre on the South Bank—as a model to Europe, a Calder Hall of the drama—will begin this year."

A note in the *Manchester Guardian* uses the term in a different way. Discussing the nature of railway tea it is said:—

> "Perhaps the superiority of tea made at home arises from the water being boiled at atmospheric pressure rather than in a miniature Calder Hall."

* * *

It is some time since I visited Billingsgate Market where there are many interesting things to be seen and (of course) heard. One of the most interesting was the arc lamp installation, one of the few surviving systems of its kind. Now, I am rather sorry to learn from *London Electricity* (the magazine of the London Electricity Board and the London Division of the C.E.A.), these lamps have been replaced by more modern lighting. They were installed in 1910 and were in continuous service (forty-eight of them) until last December. The new installation consists of 174 300 W and three 1,000 W tungsten-lamp fittings, representing a load of about 55 kW—against the arc lamps' 21 kW.

* * *

Demarcation of duties in shipyards is a constant source of trouble nowadays but it also arose fifty years ago at Devonport Dockyard. In this case it was not trade unions but departmental touchiness that seems to have been the trouble. An electrical department had been set up and, it was reported in the *Electrical Review* of 26th April, 1907, that when the transfer of duties took place

> "the electrical engineer not only assumed responsibility for the electrical equipment, but also continued the system under which his men performed the work of electrical fitters, and of ship-fitters and shipwrights also, and that of joiners occasionally thrown in, although the responsibility for the strength and watertightness of the portions of the hull operated on by his men continued to be vested in the constructive manager. The increase in electrical appliances both ashore and afloat has drawn special attention to the matter, and the Admiralty has now issued special instructions defining the duties and responsibilities of the respective departments."

Switzerland's Electrical Trade

In spite of small inflationary pressures within the country, economic surveys forecast a continuation of the favourable industrial development of Switzerland in recent years. During the past year increased industrial output, though in some cases limited by shortage of skilled labour, balanced the rising home demand. The Government's liberal trade policy, coupled with higher productivity, should enable Switzerland to maintain price stability. The persistence of a foreign payments surplus did not seriously affect inflationary pressures and the rise of gold and foreign exchange reserves was limited by considerable capital exports to finance developments in the rest of Europe in connection with loans issued by the International Bank for Reconstruction and Development. As about 60 per cent of Switzerland's foreign trade is conducted with the O.E.E.C. countries, proposals for the establishment of a European Free Trade Area were on the whole favourably received, though the country may benefit less than some others.

Although Switzerland's electrical trade, as shown in Fig. 1, has not expanded at the same rate as that of other Continental competitors, her rivalry was felt last year.

Among Switzerland's trade partners, the United Kingdom ranks fifth after West Germany, United States, France and Italy. Common frontiers and language have helped Continental competitors considerably to gain the main share of the Swiss market in the whole range of electrical products; American exports mainly consist of domestic appliances, car accessories and radio equipment. The table gives details of Switzerland's trade by principal products, markets, and supplying countries. (£1=12·2 Swiss fr.)

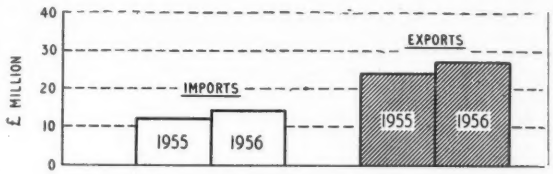


Fig. 1.—Swiss foreign electrical trade, 1955–56

Among Swiss electrical exports "dynamo-electric machinery" ranks among the principal products. Apart from deliveries to her traditional Continental and South American markets, Switzerland booked orders for heavy plant for China and some Eastern bloc countries. On the import side, radio receivers and domestic appliances account for the bulk. This applies particularly to the United Kingdom's exports, which last year increased by about £100,000.

In order to guard against future power shortages Switzerland plans to have two experimental atomic reactors in operation by 1958 and two companies have been recently formed for the purpose.

Switzerland is essentially a buyers' market and a very discriminating and competitive one; it is almost entirely free from restrictions. A high standard of after-sales service, particularly for domestic appliances, vigorous salesmanship, sales appeal of the goods, trilingual literature, and keen prices with shortest delivery periods are needed for success in this market.

SWISS ELECTRICAL TRADE 1956 (fr. 000)

Product	Imports	Exports
Steam engines and turbines	856	42,656
United Kingdom	196	1,133
West Germany	526	70
France	77	1,124
Belgium	2	7,707
Holland	—	7,298
Spain	—	8,229
Poland	—	1,324
Jugoslavia	—	1,166
China	—	2,473
Canada	—	2,504
Venezuela	—	2,148
Argentina	—	1,195
Water turbines and pumps	12,943	37,955
United Kingdom	873	560
West Germany	6,808	3,211
Austria	78	5,153
France	822	2,854
Italy	450	1,044
Belgium	263	2,549
Holland	271	2,181
Spain	—	2,082
Finland	—	1,471
India	—	1,026
United States	2,301	703
Mexico	—	2,049
Venezuela	—	2,215
Brazil	—	1,248
Dynamo-electric machinery and transformers	26,719	119,783
United Kingdom	1,688	4,236
West Germany	16,830	6,703
Austria	619	2,853
France	1,170	10,624
Italy	1,519	2,772
Belgium	301	6,112
Holland	1,243	7,350
Spain	—	5,712
Portugal	—	3,435
Denmark	95	1,085
Norway	—	3,589
Sweden	520	1,575
Finland	—	1,069
Poland	—	2,207
Jugoslavia	—	1,257
Egypt	—	9,019
Saudi Arabia	—	1,025
India	—	7,242
China	—	2,147
Canada	62	5,100
United States	2,590	7,991
Mexico	—	1,247
Colombia	—	3,230
Venezuela	—	2,595

Product	Imports	Exports
Dynamo-electric machinery, etc. (*contd.*)		
Brazil	—	4,277
Argentina	—	1,368
Peru	—	1,482
Australia	—	1,416
New Zealand	—	1,973
Electrical control apparatus and instruments	10,575	33,441
United Kingdom	1,521	368
West Germany	4,378	2,869
France	801	3,206
Italy	76	3,056
Belgium	22	3,867
Holland	629	3,052
Norway	2	1,880
Sweden	62	2,371
Czechoslovakia	1	1,487
India	—	1,867
United States	2,886	245
Radio receivers	49,244	24,304
United Kingdom	3,480	1,002
West Germany	30,120	905
France	2,147	2,008
Italy	772	1,952
Belgium	78	1,419
Holland	6,025	1,823
India	—	1,891
United States	5,793	208
Telephone and telegraph apparatus	6,678	19,191
United Kingdom	125	209
West Germany	2,892	909
Italy	102	7,488
Belgium	2,957	912
Holland	373	6,214
Electric clocks	858	1,192
United Kingdom	57	12
West Germany	602	40
Vehicle lighting equipment	2,244	1 427
United Kingdom	210	18
West Germany	1,242	19
Ignition equipment	4,911	5,368
United Kingdom	606	226
West Germany	2,481	1,907
Accumulators, with rubber casings	1,910	2,705
United Kingdom	180	143
West Germany	764	196
United States	308	322
Ditto, others	1,229	3,030
United Kingdom	—	46
West Germany	789	176
France	141	347

Product	Imports	Exports
Insulators	1,243	3,210
United Kingdom	6	135
West Germany	186	584
Belgium	—	427
Holland	32	633
Denmark	668	82
Norway	2	630
Cables and wires, bare	1,042	3,939
United Kingdom	81	112
West Germany	592	185
France	348	220
Italy	—	339
Belgium	—	591
Denmark	—	365
Norway	—	873
Sweden	—	449
Cables, paper or rubber insulated, without lead sheathing or armouring, and insulated wire	3,213	3,781
United Kingdom	248	58
West Germany	2,236	167
Italy	337	304
Belgium	10	920
Sweden	7	215
Cables with lead sheathing	30	354
France	—	177
Cables with lead sheathing and iron armouring	98	662
Cables without lead sheathing	676	1,505
United Kingdom	19	17
West Germany	331	36
Belgium	135	242
Lamps, filament	5,859	667
United Kingdom	244	7
West Germany	1,612	74
Austria	403	33
United States	1,160	114
Refrigerators, up to 100 kg	7,627	1,575
United Kingdom	882	8
West Germany	3,874	166
France	19	347
United States	2,157	2
Ditto, 100-500 kg	3,574	492
United Kingdom	181	—
West Germany	620	35
Electric locomotives and parts	626	1,675
United Kingdom	—	166
West Germany	389	75
United States	216	—
Bolivia	—	1,108

PARLIAMENTARY REPORT

REPLYING to Mr. Warbey in the House of Commons, the Prime Minister (Mr. Macmillan) said that the United Kingdom Atomic Energy Authority was prepared to supply natural uranium fuel elements for reactors made in the United Kingdom. The graphite-moderated gas-cooled type of reactor, as at present designed, did not require enriched fuel. The availability of enriched uranium was limited by the capacity of the Authority's diffusion plant at Capenhurst and by the other calls upon it, but a part of the total output had been set aside to provide fuel for reactors sold abroad of a type requiring enriched fuel.

Clean Air Council

Mr. Moyle asked the Minister of Housing and Local Government if he could announce the names of the chairman and members of the Clean Air Council with a view to implementing the provisions of the Clean Air Act, 1956.

Mr. Brooke said the Act provided that the Minister should be the chairman of the Clean Air Council. He hoped to be able to announce the names of the other members of the Council shortly.

Model of C.E.A. Nuclear Station

Mr. Nabarro asked the Paymaster General whether he would arrange for a large-scale model of a nuclear power station, of the Bradwell or Berkeley type, to be displayed within the Palace of Westminster.

Mr. David Renton replied that the Central Electricity Authority's large-scale model would be displayed in the Upper Waiting Hall from 30th April until 10th May.

Chinese Market

Mr. Selwyn Lloyd, the Foreign Secretary, informed Mr. Lewis that, following the Bermuda conference, the United States Government had made new proposals for reviewing the lists of goods banned from export to China. The Government would study these proposals in consultation with other members of the Paris Consultative Group.

Mr. Frank Allaun asked the President of the Board of Trade whether his attention had been drawn to the fact that Sweden, Switzerland and Western Germany had been shipping substantial quantities of electrical power station equipment to China in recent months; and when he intended to permit British manufacturers to accept orders for such equipment.

Sir David Eccles said that shipments from Western Germany would have been made in conformity with agreements reached in the Paris Consultative Group. Neither Sweden nor Switzerland were members of the Paris Group and he did not consider that the nature and volume of exports from those countries to China were such as to prejudice the effectiveness of the controls maintained by the members of the Group. British manufacturers were already permitted to export electrical generating equipment to China within the limitations of the exceptions procedure.

Defence Debate

During the defence debate Mr. Stokes called attention to the shortage of steel. He said that the atomic energy development plan was "mopping up" steel at a rate which nobody realised. He was importing steel from Australia to go into machines working in Northampton at about 50 per cent above the price he paid for steel here.

Mr. Sandys, the Minister of Defence, announced that the size of the Forces would be reduced in the next five years from 700,000 to 375,000. Among the 300,000 men and civilians who would be released would be a considerable number of much-needed scientists and technicians. The skill and energy of these people, when transferred to productive work, would undoubtedly make an appreciable difference to the strength of our economy at home and abroad.

Metric System

Mr. Owen asked the Government if they were aware that India had introduced the metric system and, in view of the growing tendency of Commonwealth countries to favour this system, if they would give further consideration to the recommendations in the report of the Hodgson Committee.

Mr. F. J. Erroll, Parliamentary Secretary, Board of Trade, said the Government were keeping in touch with developments. At present they were not prepared to proceed with the recommendation that the imperial system of weights and measures should be abolished in favour of the metric system.

Effects of E.M.I.-Ferguson Arrangement

Mr. Hunter asked the Minister of Labour if he was aware of the merger between E.M.I. and other radio companies, which was likely to cause serious unemployment in the Feltham area of Middlesex, and what action he proposed to take to provide alternative employment to those affected. Mr. Pargiter asked a similar question.

Mr. Macleod said that although no redundancy had been declared, the firm in question might have to discharge between 2,600 and 3,000 workers in the next few months. All those concerned would be invited to register with his Department for other employment as soon as it was known which workers were to be discharged and everything possible would be done to submit them to vacancies.

Mr. Hunter said that the merger would leave over 200,000 sq ft of factory space vacant and it was not in the local or national interest that this should not be utilised. Would the Minister see what could be done?

Mr. Macleod said he would. It was always possible to make plans for workers who were to be displaced when adequate notice was given. Long notice was given on this occasion and his Ministry's officers were in touch with the firm.

Switchgear at Bradwell

In reply to a question by Mr. Harrison, who said he believed that in addition to the nuclear power station at Bradwell, switchgear was now to be built on 70 acres, Mr. Renton said that the recent inquiry concerned the building of the power station. The switchgear was a separate item, connected with distribution.

Mr. Harrison said it was disgraceful that when planning permission was given for one project, subsidiary building should be allowed which was not in the plan. It was essential that there should be some co-ordination.

Mr. Renton said there was co-ordination and there was no strong evidence of any lack of it.

Safety of Domestic Washing Machines

Mr. Hastings asked the Home Secretary how many people were electrocuted through the use of domestic washing machines and boilers during the last year of which he had a record, and what by-laws existed to make regular inspection obligatory.

Mr. Butler said there were no fatal electrical accidents due to faulty domestic washing machines or boilers in 1956. No power of compulsory inspection of such machines existed under by-laws.

Fuel-Saving Allowances

The Chancellor of the Exchequer proposes to add the following equipment, *inter alia*, to the list of fuel-saving plant qualifying for the investment allowance:—Fuel meters affixed to boiler or other installations; heat pumps installed solely for heating purposes; and capacitors installed for the purpose of improving power factor.

Fuel and Power Resources

It was announced before the House adjourned for the Easter recess that a full-scale debate on the country's fuel and power resources, including the nuclear power programme, would take place in the Commons on Tuesday next, 30th April.

PERSONAL AND SOCIAL

News of Men and Women of the Industry

Mr. A. J. Young, B.A., B.Sc., who has been president of the Society of Instrument Technology for the past three years, retires from that office after the annual meeting on 28th May, and **Sir Harold Hartley,** G.C.V.O., F.R.S., has been elected to succeed him as president of the Society.

The Eastern Electricity Board has appointed **Mr. W. T. Langfield,** A.M.I.E.E., Associate I.Mech.E., as district manager, South West Essex District, in succession to **Mr. R. W. J. Benyon,** who is now the manager of the Essex Sub-Area of the Board.

Mr. W. T. Langfield

Mr. Langfield, who has been the Board's district manager at Northwood, was an articled pupil in 1922 of Mr. C. L. E. Stewart at the Rawstenstall electricity and transport undertaking and after a period as a junior engineer he went to Hull as junior assistant mains engineer and subsequently held appointments in Croydon, Bath and Beckenham. In 1946 Mr. Langfield became deputy borough electrical engineer and manager of the Heston and Isleworth undertaking and on nationalisation became mains engineer of No. 1 Sub-Area of the Southern Electricity Board. He took up the appointment of district manager of Northwood in February, 1950.

Mr. G. A. Young has announced his intention of retiring from executive management, and he will cease to be the assistant managing director of Richard Thomas & Baldwins, Ltd., but will remain a member of the board. The following new appointments will take effect as from 1st June:—**Mr. W. F. Gilbertson** (at present deputy general manager and works superintendent of the Ebbw Vale section) to be executive assistant to the managing director; **Mr. Cedric T. Thomas** (at present general manager, Redbourn section, Scunthorpe) to be general manager of the company's Ebbw Vale section; and **Mr. Campbell Adamson** (at present assistant general manager, Redbourn) to be general manager of the company's Redbourn section.

The British Transport Commission announces that by mutual arrangement, **Mr. E. L. Gethin,** B.Sc.(Eng.), A.M.I.E.E., supplies and production adviser to the Commission, is leaving its service at the end of May. Mr. Gethin joined the staff of the Commission in June, 1955, as supplies and production adviser. The Commission says that it has recently reviewed the organisation of the supply side of its business, and in this examination, Mr. Gethin has made a substantial and constructive contribution. As a result a plan of reorganisation has been produced, which has been accepted in principle by the Commission. The new organisation involves a separate Contracts Branch, and the absorption of the responsibilities of the post of supplies and production adviser by the other advisers, by the chief supplies officer and in the new post for the Contracts Branch. It does not include a post comparable in status to the one which Mr. Gethin has occupied.

Before joining the Commission, Mr. Gethin was deputy chief contracts officer to the Central Electricity Authority, having previously been purchasing officer to the Southern Electricity Board.

Mr. R. P. Mason, commercial manager, and **Mr. C. L. Chapman,** chief development engineer, of Venner Accumulators, Ltd., New Malden, Surrey, leave by air on 3rd May for New York to attend the annual conference of licensees of the Yardney International Organisation. They will return on 16th May. The conference is called yearly for an exchange of ideas on improved methods of manufacture and design, and for discussion of uses of the lightweight silver-zinc accumulator based on the Andre-Yardney system.

The **Leicester Electrical Society** held its 10th annual dinner-dance at the Grand Hotel, Leicester, on 4th April. Among the guests were Mr. D. H. Parry (manager, Leicester Sub-Area, East Midlands Electricity Board); Mr. R. H. Gill (Midland Dynamo Co., Ltd., chairman of the Leicester Branch, E.C.A.) and Mr. Moore (president, Nottingham Electrical Club).

Mr. Gill proposed the toast of the Society and referred to some of the developments that had taken place in the electrical industry. Mr. K. Broom, president of the Society, responded, and said that in a small way it tried to meet the requirements of its members in obtaining discussion with experts on these developments. Mr. J. J. Hayman, vice-president, proposed the toast of the guests, and Major H. E. Knight responded.

At the annual dinner-dance of the Leicester Electrical Society. Left to right: Mrs. Gill, Mrs. Broom, Mr. K. Broom (president) and Mr. R. H. Gill (chairman, Leicester Branch, E.C.A.)

Mr. G. W. Godfrey, of E. K. Cole, Ltd., has returned to this country from Australia where, as a director of Ediswan-Ekco (Aust.) Pty., Ltd., he has during the past nine months been concerned with the setting-up of production facilities for television receivers; he has also been advising on marketing.

Mr. J. Murden has been appointed manager of the Glasgow service depot of "Servis" electric washing machines (Wilkins & Mitchell, Ltd.), at 1047/9, Argyle Street, Glasgow.

Last week the **G.E.C. Dramatic Society** presented "The Shining Hour," a play by Keith Winter, at the Cripplegate Theatre, London, E.C. The cast did their best with the somewhat synthetic emotions and marital complications of the Linden family cooped up in a remote Yorkshire farmhouse. Honours were equally shared by Joan Morrison, Florence Scantlebury, Michael Hobbins, Victor Sallows, Brenda Stewart and Roy Appleby. Bunty Hill was the producer. A donation from the proceeds is being sent to the National Fund for Poliomyelitis Research. The National Spastics Society benefited by £50 from the Society's last production.

Clang, Ltd., celebrated its 25th anniversary on 4th April, the date on which it became a limited company, although it had been in being before

that date. At an informal gathering in the works canteen the employees presented Mr. C. G. Lange, the founder and managing director, with a model in porcelain of a black cat mounted on an ebony plinth with a suitable inscription engraved on a silver plate, and to Mrs. Lange, also a director of the company, a bouquet of flowers.

The education section of Marconi Instruments, Ltd., has been strengthened by the appointment of **Mr. J. J. Bliss,** B.Sc. (Eng.), Graduate I.E.E., as the education officer. Mr. Bliss is a graduate of Nottingham University and went to the technical literature section of Marconi Instruments in 1951. He has been a part-time lecturer at Hatfield Technical College, Herts. During the war he served as a sea-going officer with the Marconi International Marine Communication Co.

Mr. J. J. Bliss

Mr. J. E. C. Bailey, C.B.E., has been elected chairman of the British Scientific Instrument Research Association, his term of office to extend until July, 1960. The Association has formed an Automatic Control Research Panel under the chairmanship of **Mr. A. J. Young,** head of the I.C.I. Central Instrument Laboratory.

Mr. J. D. Morton, B.Sc., M.I.Mech.E., M.I.E.E., president of the Association of Mining Electrical and Mechanical Engineers, has been appointed managing director of Siemens-Schuckert (Great Britain), Ltd., following the retirement of Mr. A. E. Barton, M.B.E., M.I.Mech.E.

Mr. J. D. Morton

Pollard Bearings, Ltd., has appointed **Mr. John M. Armitage** as advertising and publicity manager. Mr. Armitage previously held a senior post on the publicity staff of Crofts (Engineers), Ltd.

Dr. J. N. Aldington and **Sir Nicholas Cayzer,** Bt., have been elected directors of Associated Electrical Industries, Ltd.

Mr. J. D. Howden Hume, production engineer, and **Mr. J. D. Young,** secretary, have been appointed directors of James Howden & Co., Ltd. **Mr. J. S. A. Pearson,** controller, and **Mr. N. Zoller,** general works manager, have been appointed local directors.

Everett Edgcumbe & Co., Ltd., Colindale, held their annual Long Service Association dinner on 11th April at "The Rest," Kenton. Members, who have served not less than twenty-five years, together with guests, numbered 37. A new member, Miss B. A. Osman, was presented with a gold watch. Speeches were made by the chairman of the Association, Mr. R. E. Everett, the Earl of Mount Edgcumbe, Mr. T. Coughtrie and Mr. H. B. Carpenter. A pleasant evening was rounded off by entertainment at the piano by Mr. Philip Lewtas.

Mr. D. W. Kaye (chairman, North Metropolitan Branch, E.I.B.A.), Mr. H. Riley (president, E.I.B.A.), Mrs. Riley, Mr. H. Senior Fothergill and Mrs. Kaye, at the branch annual dinner held at St. Albans on 12th April

The directors of **Baird & Tatlock (London), Ltd.,** gave their annual dinner to the staff at the Waldorf Hotel on 26th March. During the evening gold watches were presented to Mr. W. F. Ellsmore and Mr. B. C. Webb, in recognition of fifty years' service with the company. A number of members of the staff who had previously received gold watches for fifty years' service were also present.

Mr. D. C. Davies has joined the staff of Chilton Electric Products, Ltd., as technical sales engineer.

Mr. W. Lorimer, who joined the London service depot of the English Electric Co.'s Appliance and Television Division in 1952, has now been made responsible for sales training and service instruction courses. **Mr. J. C. Andrews,** former sales training officer to the Division, has been promoted to area manager covering South and South-East England. He will be working from the company's Tonbridge offices.

The annual dinner-dance of the North Metropolitan Branch of the **Electrical Industries Benevolent Association** was held at St. Albans on 12th April under the chairmanship of Mr. D. W. Kaye. There were 170 people present, the guests being Mr. Harry Riley, the president of the Association, with Mrs. Riley, and Mr. H. Senior Fothergill, secretary. A number of prizes were distributed. It is anticipated that the amount which will be handed to the Association will be in excess of £100.

Mr. A. D. Priestland, M.B.E., M.I.E.E., and **Mr. P. E. Trier,** M.A., A.M.I.E.E., have been appointed directors of the Mullard Radio Valve Co., Ltd. Mr. Priestland joined the company in 1935 as a technical assistant, and in 1940 was made responsible for valve manufacture at the factory at Blackburn. In 1951 Mullard Blackburn Works, Ltd., was formed and Mr. Priestland was appointed a director of that company. Mr. Trier, who is manager of the research laboratories, graduated as a wrangler in the mathematical tripos at Cambridge. He was engaged at the Admiralty Signal and Radar Establishment from 1941 to 1950, and during the war developed direction finding techniques, in the metric and centimetric regions. During the later part of his service with the A.S.R.E. he was head of the V.H.F. Communications Group. He joined Mullard Research Laboratories in 1950 as head of the Communications and Radar Division.

Mr. A. D. Priestland

Mr. P. E. Trier

OBITUARY

Mr. G. H. House.—The death occurred recently at the age of sixty-one of Mr. G. H. House, who was for 44 years with Pritchett & Gold and E.P.S. Co., Ltd. For many years Mr. House was a battery inspector in Scotland. Later he became representative for the whole of Scotland and the border counties.

Mr. George Albert Jackson, for nineteen years managing director of Freeman's (Electrical Contractors), Ltd. (members of the E.C.A.), of Brierley Hill, has died; he was seventy-three.

Mr. E. J. Bennett.—The death occurred on 15th April of Mr. E. J. Bennett, works superintendent and labour manager of Kent Bros. Electric Wire Co. & E. H. Phillips, Ltd. Mr. Bennett, who was seventy years of age, had been in the company's employ for thirty-eight years.

E.R.A. Reports

Cable Ratings.—Two recent reports issued by the British Electrical and Allied Industries Research Association deal with the current ratings of cables. Both have been prepared by R. G. Parr, B.Sc.(Eng.). In report Ref. F/T 188, "Current Carrying Capacity of Small Cables for Domestic and Small Commercial Installations" (price 12s 6d, from E.R.A., Thorncroft Manor, Dorking Road, Leatherhead) tests carried out to determine the current carrying capacity of small cables used for domestic and commercial installations are described. Current ratings corresponding to a 16·7 deg C temperature rise are given for four sizes of cable with different coverings and modes of installation, run in single-circuit, double-circuit, three-circuit and four-circuit groups. The average relation between temperature rise and current for the several types tested is given to permit calculation of the current rating corresponding to any other temperature rise. Relative effects on the temperature rise of a cable of a cold brick wall and of the hardboard used for the specimens are considered in an appendix. A note is also included on the temperature rise of cables on moderate overloads not immediately disconnected by fuses.

Report Ref. F/T 191 (price 10s 6d) gives experimentally determined current ratings at 50 c/s and at 400 c/s for 660 V three-core p.i.l.c., s.w.a. unserved cables to B.S. 480:1942 in air, and for three single-core v.r.i. cables, taped and braided to B.S. 7:1946, run in heavy gauge screwed conduit in air.

Ratings are given corresponding to the temperature rises of 45, 50 and 55 deg C for paper-insulated and 20 deg C for v.r.i. cables. The information given can without difficulty be used to cover other temperature rises of the same order. The report also includes data on the a.c. resistance and reactance at rated current.

Characteristics of D.C. Corona.—In E.R.A. Report Ref. L/T 329, "Electrical and Optical Characteristics of D.C. Corona Discharges in Air at Atmospheric Pressure," by B. Murphy, M.Eng., Ph.D. (price 21s), d.c. positive-point to plane corona discharges in untreated room air have been studied with the aid of a photo-multiplier, wide band (distributed) amplifiers and a high-speed cathode-ray oscillograph.

The results indicated that a pulsed form of discharge did not necessarily occur. When a pulsed form did occur, the pulses were associated with streamers propagating from the positive point toward the negative plane. Direct evidence was obtained that some ionisation and considerable excitation occurred ahead of and around the streamers. Streamers did not branch until after they began to decay. Branches did not propagate simultaneously. This accounted for the characteristic visual form of the self-maintained positive point corona discharge in air. Calculated ratings for p.i.l.c. cables are also given.

All the results could be explained satisfactorily on the latest ideas of the streamer theory, when due consideration was given to increase in the excess positive space charge in a streamer as it began to die away and electrons were removed from the channel.

Oscillograph with Automatic Brilliance Control.—The Duddell vibrator is widely used in oscillographs for recording transients of power systems. It has, however, certain disadvantages, i.e. a poor h.f. response, low impedance and need of an intense light source, which have prompted the E.R.A. to construct an oscillograph for this class of work. Report Ref. G/T 307, "A Four-Channel Cathode-Ray Oscillograph with Automatic Brilliance Control," by M. T. Cree, A.M.I.E.E. (price 6s), describes the design and performance of the oscillograph in which low-voltage cathode-ray tubes are used. The speed of the film or recording paper is of the same order as that usual with electromagnetic oscillographs, i.e. 200 in/sec.

Experience has shown that the very high frequency response of the cathode-ray tube is not wasted, because pulses too short to be recorded by a Duddell vibrator are recorded by vertical lines indicating their presence and amplitude. Because a spot, brilliant enough to record these short pulses, is too bright at low frequencies an automatic brilliance control is used which matches the brilliance of the spot to the rate of change of the voltage being recorded.

No new principles are involved in the instrument, but it may be of use to those having occasion to record transient phenomena of long duration (up to 10 sec), which may include transients too rapid to be recorded with an electromagnetic oscillograph.

New British Standards

Flameproof Enclosure (B.S. 229:1957, price 7s 6d).—A revised edition of what is, in effect, the key specification for the enclosure of electrical apparatus for use in situations where inflammable or explosive gases or vapours may be present, has recently been issued by the British Standards Institution.

Following continued research by the E.R.A. in collaboration with the Safety in Mines Research Establishment, the method of assessing the statistical maximum safe-gap for the gases and vapours has been reconsidered, with the result that a more precise method of grouping than that of the 1946 edition of the Standard has been evolved. Requirements in Group II for the sleeve bearings of large rotating machines for gases and vapours have been changed to make the construction and operation of the apparatus more practicable.

Presentation and arrangement of the subject matter of the Standard has been changed in the interests of greater clarity. As in previous editions, the apparatus mounted in the enclosures is not specified in detail; for such apparatus reference should be made to the appropriate British Standard. Information on the experimental work, referred to above, which provides the basis of this revision of B.S. 229 is given in an annex which also includes guidance regarding gases which are under examination but for which insufficient data are as yet available to permit requirements to be specified.

Conditions for Testing and Pre-Conditioning of Dielectrics (B.S. 2844:1957, price 3s).—This memorandum has been prepared to bring together in a single publication the conditions of temperature, atmospheric humidity and liquid immersion which are in general use in the United Kingdom for the testing of electrical insulating materials and their pre-conditioning before test. It is intended that, as far as possible, new and revised British Standards for electrical insulating materials shall specify conditions for testing and pre-conditioning selected from those given in this Standard, and that these conditions should be generally adopted in the testing of such materials.

Copies of the above Standards may be obtained from the British Standards Institution, 2, Park Street, London, W.1, at the prices stated.

INDUSTRIAL NEWS

First Restrictive Practices Cases

The Registrar of Restrictive Trading Agreements is required by the Restrictive Trade Practices Act to take proceedings before the Restrictive Practices Court on all registered agreements, but the Board of Trade may direct him as to the order in which cases are to be taken. The Board of Trade has now directed the Registrar to take as the first cases agreements involving registrable restrictions in relation to the supply of bread, corrugated paper, cotton yarns, flour, hard fibre cordage, high conductivity copper semi-manufactures, proprietary medicinal preparations, school milk, shell boilers, structural steelwork, and woollen or worsted pile carpets. The formal commencement of proceedings is by the issue of a "Notice of Reference" in respect of the agreements concerned, and Notices will be issued within the next few weeks.

In each case the Court has to decide whether the restrictions contained in any agreement by virtue of which it is registrable are contrary to the public interest or not. The duty of the Registrar is to give the Court all possible assistance in reaching its decision and he will therefore be getting into touch shortly with anyone he believes to be able to assist the Court with evidence about the agreements listed above. Anyone else who may be able to provide evidence from his own experience of results of any of these agreements which he thinks affect the public interest is asked to communicate as early as possible with the Solicitor to the Registrar at Chancery House, Chancery Lane, London, W.C.2.

The reference to high conductivity copper semi-manufactures relates to recommendations for selling prices and discounts. In the case of structural steelwork it concerns the fixing of prices for steelwork for buildings and of maximum and minimum prices for its erection.

Motor Vehicle Equipment Inquiry

The Board of Trade has referred to the Monopolies Commission for investigation the supply of the following classes of electrical equipment for motor vehicles:—Batteries; ignition coils, magnetos, distributors, and ignition suppressors; dynamos, current-voltage control units, starter motors; windscreen-wiper motors; air-moving devices for heating or ventilating equipment; clocks, ammeters, equipment for indicating (whether by means of warning light, dial or otherwise) ignition, water temperature, oil pressure or fuel level; headlamps, sidelamps, stoplamps, tail-lamps, foglamps, spotlamps, number plate illumination lamps, flasher indicator lamps, reversing lamps, horns, trafficators, relay units for lamps or horns, flasher units for indicator lamps or trafficators; and sparking plugs, compression ignition heater plugs.

The Board of Trade states that any person or organisation wishing to offer evidence should write to the secretary, Monopolies Commission, 8, Cornwall Terrace, Regents Park, London, N.W.1.

Scottish Contractors' Conference

The annual conference of the Electrical Contractors' Association of Scotland will be held this year at Dunblane Hydro from 16th to 19th May. The first session will take place on the Thursday afternoon, with the annual meeting of the S.E.C.T.A., Ltd., on the Friday morning and the official reception and dinner in the evening. The Saturday programme includes the customary "East *versus* West" golf match and the annual general meeting of members in the afternoon.

E. N. Bray's New Works

On Wednesday last week the new works of E. N. Bray, Ltd., at Britannia Road, Waltham Cross, Herts., were formally opened by Mrs. Hoyle, wife of Mr. J. V. Hoyle, a director of the United Molasses Co., Ltd., who deputised for Mrs. G. W. Scott, wife of the managing director of the United Molasses Co., Ltd., who was indisposed.

In inviting Mrs. Hoyle to cut the tape inaugurating the new works, Mr. Hoyle said that the works at Whipps Cross had been developed to capacity and working conditions had become difficult. The new works were three times the size of the old works and would not only enable them to expand their lines of products, but would also make it possible for them to manufacture certain components hitherto obtained elsewhere.

Mr. E. N. Bray, the founder of the company, joined with two other gentlemen in 1905 to form the firm of Bray, Markham & Reiss for the manufacture of contactors and control gear, at Walthamstow. The business was acquired by the Electrical Apparatus Co. in 1921 and in the following year Mr. Bray decided to start afresh. He went to his yacht on the Norfolk Broads where he produced a complete new range of contactor designs. He returned to Walthamstow and with a number of people who had been with him originally, started the company of E. N. Bray, Ltd., at Wood Street, Walthamstow, to manufacture contactors and electrical control gear. In 1947 he retired from active control in the business although he remained a director until his death in 1954. The United Molasses Co., Ltd., acquired all the share capital of E. N. Bray, Ltd., in 1955 and later reconstituted the board of directors.

In September last the factory at Waltham Cross was acquired in a part-finished state. This has an area of 60,000 sq ft as compared with 25,000 sq ft for the old Whipps Cross Works, and there is sufficient room on the site to enlarge to more than twice the present size. The factory employs some 200 workpeople with a staff of approximately 30. It is the company's intention to expand the business of contactor and motor control gear manufacture with emphasis on equipments to meet customers' specific needs. Steps are being taken to modernise designs and production methods, and to establish a sales force.

Continuous-Slagging Boiler

A 120 MW reheat boiler unit which Simon-Carves, Ltd., is to build for the C.E.A. North West, Merseyside and North Wales Division at Padiham "B" power station, near Burnley, will generate 860,000 lb of steam per hour at 1,600 lb/sq in and 1,010 deg F, with reheat of 785,000 lb/hr to 1,005 deg F, these figures relating to the steam conditions at the superheater outlet.

The boiler, which will be fired by pulverised fuel in twin primary furnaces, is representative of an important development in British practice in that it will be of the continuous-slagging type. The primary aim of slagging furnaces is to eliminate the handling and disposal of fine dust, with its attendant nuisance.

The essential feature of the continuous system is that the dust

The new factory of E. N. Bray, Ltd., at Waltham Cross

collected from the boiler passes to the dust extraction plant and is re-cycled for slagging in the primary combustion chambers, from which it is continuously discharged together with the remainder of the ash which is slagged before escaping from the combustion zone: the discharged slag enters a water-filled trough, where disintegration takes place. The whole of the fine dust, which would otherwise present a troublesome disposal problem, is thus converted into a hard, clean, pellet-like slag, which can be put to industrial use.

The dust electro-precipitation plant associated with this boiler unit will also be built by Simon-Carves, Ltd. It will have a guaranteed collection efficiency of 98·6 per cent.

New Davis & Timmins Depot

To serve a wide area of the Midlands, covering eight counties, Davis & Timmins, Ltd., have built a depot at Tyseley, Birmingham, at which large stocks will be carried. The manager is Mr. J. Whitelock.

The new premises were officially inaugurated last week. Mr. A. J. Wright, who deputised for the chairman, Mr. L. F. le Neve Foster, in an introductory speech, mentioned that the considerable growth of the company's business in the Midlands had compelled them to make more adequate arrangements. Mr. R. J. Mitchell, chairman of the Purchasing Officers' Association, declared the new depot open.

Prices of Materials

In the accompanying table we give the basis prices of the more important materials used in the electrical industry. The figures given are the selling prices and are those quoted on Tuesday last.

ALUMINIUM ingots	ton £197 0s 0d
COPPER, H.C. Electro	ton £240 10s 0d
Fire Refined 99·70%	ton £239 0s 0d
Fire Refined 99·50%	ton £238 0s 0d
COPPER Tubes	lb 2s 3½d
Sheet	ton —
H.C. wire and strip	ton £290 5s 0d
LEAD, English	ton £111 5s 0d
Foreign	ton £110 0s 0d
MERCURY	flask £86 0s 0d
TIN, block (English)	ton £777 10s 0d
ZINC, G.O.B. Foreign	ton £98 5s 0d
Electrolytic	ton —
BRASS Tubes (solid drawn)	lb 1s 11½d
Sheet	ton —
Wire	lb 2s 8⅝d
PHOSPHOR BRONZE Wire	lb 4s 0d
PLATINUM	oz £34 0s 0d
RUBBER, No. 1 R.S.S. spot	lb 27⅜d—27⅝d

Water Turbine for Northern Canada

A water turbine recently left the Kendal works of Gilbert Gilkes & Gordon, Ltd., for the far North West of Canada. It is a 3,000 h.p. Francis turbine which will be installed in the Northern Canada Power Commission's Mayo River scheme. Operating on a head of 110ft of water, the turbine has a fabricated steel spiral case, the inlet to which is isolated by a 6ft bore butterfly valve. After being shipped from Liverpool to Vancouver, the turbine will be taken again by sea to Skagway in the Alaskan Panhandle. It will then be transported by rail to Whitehorse and for the final 300 miles by road to its destination in the Yukon Territory, only 200 miles from the Arctic Circle. The power generated by the hydro-electric unit is being purchased in bulk by the United Keno Hill Mine. The order for this turbine was obtained by Gilkes in the face of strong competition from Canadian and American manufacturers, and one of the chief reasons for the company's success was the very short delivery time it was able to offer.

A large water turbine leaving the Kendal works of Gilbert Gilkes & Gordon for shipment to North West Canada

E.A.W. Midlands Conference

The 14 East Midlands Branches of the Electrical Association for Women held a conference at Nottingham University on 16th April which was attended by over 300 delegates. The theme was "Clean Air Through Electricity" and the principal speakers were the Lord Mayor of Nottingham (Alderman W. J. Cox); Mr. C. R. King (chairman, East Midlands Electricity Board), who proposed the toast of the Association; and Miss Mary George (director, E.A.W.), who replied to the toast. The chair was taken by Mrs. A. B. Lewis, a member of the Association's National Executive Committee, and the conference was arranged by Mrs. A. L. Hayes, the area organiser.

Isolated Temperature Measurement

The source furnace in "Hermes," the Harwell active electromagnetic isotope separator, presented engineers of the United Kingdom Atomic Energy Authority and Honeywell-Brown, Ltd., with the problem of providing close control and a continuous record of furnace temperatures in such a manner that the Authority's staff could use the instruments without coming into contact with the 50 kV potential of the source unit's power supplies.

The following description of the system now in use may anticipate difficulties elsewhere. An electronic potentiometer recorder with a three-term (proportional, integral, and derivative) pneumatic control form is housed in the separator's high voltage supply cage. It is situated behind a "Perspex" door which is interlocked with the high voltage supply.

In addition to its normal control unit, the controller is equipped with a pneumatic transmitting element. This is connected to a miniature pneumatic recorder built into a control desk which is at earth potential; connection is by means of a polythene air line which provides the necessary insulation between the controller and the desk.

The miniature recorder, or "slave" unit, provides the plant operator with a continuous indication and permanent record of furnace temperature.

F.H.P. Motor Manufacture

We regret an error which inadvertently crept into the note with the above heading in our last issue dealing with the extensions to the fractional h.p. motor factory of the British Thomson-Houston Co., Ltd., at Newcastle-under-Lyme. We said that this factory, as extended, would be about twice as big as the Rugby works. We should have said, the *original* Rugby works.

G.E.C. Export Guide

In introducing the third edition of its useful Export Guide the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, says that it indicates that favourable export prospects for British manufactured goods continue in many major overseas markets. It classifies prospects in the thirty-four countries covered as good (14), improving (6), deteriorating (10) and bad (4).

The Guide gives particulars of imports by 34 countries of 36 commodity groups.

Last New York Tram

The sole remaining tramway route in New York State, that of the Queensborough Bridge Railway Company, ceased operating recently. More than 100 passengers travelled on the last tram.

Industrial and Factory Law

A course on industrial and factory law will be held under the auspices of the Industrial Welfare Society from

28th to 30th May at Robert Hyde House, 48, Bryanston Square, London, W.1. Mr. Harry Samuels, M.A., barrister-at-law, will be the lecturer. The course covers the legal groundwork necessary to industrial managers and executives. Particulars can be obtained from the secretary of the Industrial Welfare Society, Robert Hyde House, 48, Bryanston Square, London, W.1.

Contract Price Formulæ

The British Electrical and Allied Manufacturers' Association has issued the figures for its contract price adjustment formulæ.

In each case the rate of pay for adult male labour at 13th April is deemed to be 175s.

The "cost of materials" figures are: For electrical machinery and equipment the Board of Trade index figure published on 13th April is 182·7. For turbo-generating and allied plant: Materials used in mechanical engineering industries 181·0, blast furnaces and iron and steel melting and rolling (40 and 41), 177·6. The price of ⅜in o/d 18 s.w.g. brass condenser tubes (*Metal Bulletin*, 12th April) is 46⅝d per lb.

Electronic Digital Computer

A new electronic digital computer known as the "Metrovick 950" is now in experimental use in the Electronics Department of the Metropolitan-Vickers Electrical Co., Ltd. It is a general purpose model capable of application to a wide variety of mathematical problems in research and engineering design.

The design incorporates printed circuits on the plug-in boards and transistors are extensively used. The computer is housed in a steel framework 14ft 5in long by 4ft 10in wide by 6ft 1½in high and for convenience for shipping and installation is assembled in three units, i.e. control desk, control and power supply rack, and computing rack.

All the controls are situated on a panel; a set of 32 keys enables a number or an instruction to be set up, and further keys provide for this to be placed in any register as required. Instructions may be obeyed continuously at a high speed, or singly when the start key is pressed. If an arithmetical operation should involve an answer which is outside the range of the machine store, computation is stopped and the fact is indicated by a lamp. The input tape reader and output tape punch are on the control desk itself and the output printer is on a wheeled trolley which may be situated near the desk. It is connected to the computer by a multicore cable.

New "950" digital computer of the Metropolitan-Vickers Electrical Co.

Black & Decker in Canada

The Black & Decker Manufacturing Co., Ltd., of Toronto, announces the purchase of a factory in Brockville, Ontario, for the manufacture of portable electric tools. This is the first manufacturing plant to be established by Black & Decker in Canada and manufacturing operations are expected to begin about the end of June.

Trolley-buses for Bournemouth

An £80,000 order has been placed with the Sunbeam Trolleybus Co., Ltd., associate company of Guy Motors, Ltd., by Bournemouth Corporation. It is for twenty 62-seat double-decker trolley-buses to replace an equivalent number of vehicles supplied in 1935, when the Bournemouth tramway system was replaced by trolley-buses. Chassis for the new Sunbeams will be of the two-axle type, with Metropolitan-Cammel-Weymann 30ft bodies and Crompton-Parkinson electric traction equipment.

Extended Deferment of Call-up

Mr. Iain Macleod, Minister of Labour and National Service, stated last week in a written answer to a Parliamentary question that he had decided to extend deferment of call-up for study or training, within the framework of present policy, to cover certain classes of young men who have not hitherto been eligible. About 80,000 apprentices, learners, pupils and students are deferred from each age class under the present arrangements. These arrangements are both extensive and comprehensive and it is estimated that the new concessions will affect only a few thousand young men.

Apprentices and learners at present obtain deferment only if there are generally recognised schemes or customary arrangements in the industry or occupation for which they are being trained. This restriction no longer applies. Technicians were not previously covered by specific deferment arrangements. They have now been brought within the deferment field at a time when industry is making increased provision for the training of this type of young man. Part-time students have previously been granted deferment only if their studies were concurrent with practical training in employment. Deferment will now be granted for part-time studies alone where the standard of the examination and the qualifications aimed at are sufficiently high and where day release is granted by the employer.

There are other minor relaxations extending the deferment already allowed to certain ex-apprentices for study and training, and bringing additional categories of full-time students into scope for deferment. It is pointed out that the grant of deferment for study or training is limited to the period of training and does not affect a young man's liability to perform National Service on its completion.

Fire Prevention

The Fire Protection Association, 15, Queen Street, London, E.C.4, has issued a bulletin, "Electricity—and Fire," in which some of the common causes of electrical fires are given with advice on how these can be prevented. Copies can be obtained free from the Association.

National Society for Clean Air

At a special general meeting of the National Smoke Abatement Society held in London on 11th April, it was agreed that the Society should seek incorporation as a company limited by guarantee and without share capital, and with the new name, National Society for Clean Air.

Safety and Factory Efficiency Exhibition

The Birmingham and District Industrial Safety Group is holding its fourth Safety and Factory Efficiency Exhibition in Bingley Hall, Birmingham, from 14th to 21st June. The principal display will be an exhibit by the United Kingdom Atomic Energy Authority. In conjunction with the exhibition there will be a two-day conference dealing with the increasing use by industry of atomic energy and its by-products.

Dock and Railway Lighting

At a recent meeting of the Stoke-on-Trent Group of the Illuminating Engineering Society Mr. W. T. Souter read a paper on "Improved Lighting of Docks and Railway Yards." In this the author spoke of developments in lighting to increase the speed of night

handling operations, as a safety measure and as a means of guarding against theft.

He said that the trend of design was towards the use of grouped fittings with powerful light sources mounted at high level in a limited number of positions. Although this system was high in first cost, cabling was reduced and the operating advantages more than justified the initial expenditure.

New London Sign

A new mechanically animated display measuring 56ft 3in by 16ft has been erected at the top of Lyons' Corner House, Coventry Street, London, W.1. It has been designed, manufactured and erected by Franco Signs, Ltd., in close collaboration with the British Motor Corporation. Materials used in the manufacture of the display include nearly 3,200ft of neon tubing, 3,000ft of lead covered h.v. cable and 100 transformers. The sign includes a huge replica of the rosette emblem of the British Motor Corporation. To the right of this, three different messages are presented at intervals of ten seconds. These read first, "Morris Cars," then "Austin Cars" and finally "Buy B.M.C. Vehicles." The letters themselves are mounted on all three sides of eight triangular segments which stand side by side, each section being 12ft high and having three faces each 56in wide. At intervals these triangular columns are made to revolve one-third turn, so presenting three different backgrounds. Three new signs are therefore presented to view every ten seconds.

The new Franco animated sign in Coventry Street, London, W.1, showing the segments revolving

The mechanism is driven by a 5 h.p. motor. This is directly coupled to a magnetic clutch and brake which in turn drives a high speed reduction gear box, and then through further reduction gears mounted and directly coupled to the top of each segment. The neon tubing used in the illumination of all three messages is operated by a common set of transformers housed at the bottom of the sign for convenient access, h.v. circuits being fed to the neon tubes by specially designed switch and contact gear mounted beneath the segments. Owing to variations in the length of the three messages, there are times when certain transformers are not in use, but by means of selective switching, these are automatically cut out when not required. The electricity supply is also cut off from the transformers whilst the segments are rotating. A motor controlled flasher with mercury contacts, controls the mechanism of the display, bringing in, and releasing, the clutch and brake at the appropriate moment. This flasher also operates forty electrical circuits, each producing a different flashing sequence.

Glasgow Signalling Installation

A comprehensive scheme of colour light signalling has been brought into use covering 6½ route-miles of the Glasgow Queen Street High Level/Edinburgh Waverley main line, and certain branches, and the approach to Queen Street Station. The system is controlled from a new signal box at Cowlairs which does the work of eight signal boxes formerly in service. The work was carried out under the direction of Mr. L. J. M. Knotts, signal engineer, Scottish Region, British Railways, and the contractors for the signalling equipment were the Westinghouse Brake & Signal Co., Ltd., while the telephone, loudspeaker and train describers were provided by Standard Telephones & Cables, Ltd.

The power for the signalling and associated services is taken from two separate 415 V, three-phase, four-wire 50 c/s incoming supplies which are treated as main and standby and are automatically changed over in the event of a power failure. The three-phase supply is used for the electrically driven compressors, signal box lighting, subsidiary heating, etc., and a 240 V supply, between phase and neutral, is used for signalling. A diesel engine driven standby alternator set caters for the signalling supply in the event of both incoming supplies failing, and also provides a mechanical drive for a standby air compressor. The set comprises a Ruston Mark 4YE diesel engine and a Lancashire Dynamo & Crypto revolving armature type single-phase alternator. The output of the set is 26 kVA at 240 V, 50 c/s, single-phase at 0·9 p.f.

The main electrically driven compressors in Cowlairs power house are Broom & Wade Type EH.220, twin cylinder, water cooled machines and the 15 h.p. motors are of B.T.H. manufacture.

Anglo-Swedish Jubilee

To celebrate its fiftieth anniversary the Swedish Chamber of Commerce for the United Kingdom has published a special issue of its journal, the *Anglo-Swedish Review*. It is prefaced by messages from Sir David Eccles, President of the Board of Trade, and Mr. Gunnar Lange, Swedish Minister of Commerce. Following a brief history of the Chamber and articles on fifty years of Anglo-Swedish trade and cultural relations, there are contributions by British and Swedish authorities on various aspects of the trade between the two countries and on principal Swedish industries, as well as articles of more general interest.

Fan Manufacturers' Agreements

An agreement has been made recently between Keith Blackman, Ltd., and Prat-Daniel (Stanmore), Ltd., by which both companies will be able to offer complete draught equipment for power station and industrial work. In addition an agreement has recently been made with the Aerotec Corporation of America, which has resulted in the introduction of electrostatic precipitators to the ranges of both companies. Under this arrangement both Keith Blackman, Ltd., and Prat-Daniel (Stanmore), Ltd., are able to offer complete mechanical draught and grit arrestor equipment, comprising fans and multitubular dust collectors, which, where needed, can be supplemented by electrostatic precipitators.

Digital Computer Course

The British Council has arranged a course on "Digital Computers," to be held in London from 27th October to 9th November next. The course will include visits to various computing establishments. It is intended for scientists in industry, university teaching staff and research workers from overseas. Particulars can be obtained from the Director, Courses Department, the British Council, 65, Davies Street, London, W.1.

Infra-red Heating Installation

A new village hall at Fulmer, Bucks., opened recently by Princess Alexandra, is heated entirely by "Radisil" infra-red radiant heaters, designed and produced by Hanovia (Lamps Division of Engelhard Industries, Ltd.), of Slough. Fifteen 1½ kW "Radisil" units—of which ten are in the main hall—and four 350 W units have been installed. The total loading involved to heat the space of 28,000 cu ft is less than 24 kW.

The architect was Mr. C. B. M.

"Radisil" heaters in a village hall

Smith, A.R.I.B.A. (Slough); the main building contractors were William Hartley & Sons (Wexham) and the electrical contractors were L. Elderfield (Wexham).

Farm Electrification Course

Twenty delegates from several districts in the Merseyside and North Wales Electricity Board's area attended a farm electrification course at the Flintshire Horticultural Institute, Northop, from 8th to 12th April. The course included lectures by specialists on many aspects of horticultural science and the applications of electricity to plant and poultry growth. The subjects included "Plant Growth in Relation to Soil and its Preparation," "Light and Heat as Factors in the Germination and Treatment of Plants," "Electrical Aids in Soil Preparation," "Control of Plant Growth and Development by Electricity," "Moisture and Heat as Factors in Regeneration of Plants from Cutting," "General Problems of Glasshouse Heating," "Electrical Aids for Heating the Glasshouse," "The Economics of Commercial Poultry Rearing," "Electrical Aids for the Modern Commercial Poultry Farmer," and "Agricultural and Domestic Pumping Installations." The chairman for the course was Mr. T. R. Smith, assistant chief commercial officer of Manweb, and he and his senior assistant, Mr. L. Phillips, were responsible for the organisation and administration of the course.

Trade Announcements

E. N. Bray, Ltd., announce that their agent for many years in Glasgow, Mr. Borthwick, is about to retire and they have accordingly opened an office at 190, West George Street, Glasgow, C.2, under the control of one of their engineers, Mr. W. S. Henderson.

Thorn Electrical Industries, Ltd., have appointed Mr. D. T. Turnbull as "Atlas" lighting representative in Suffolk, Cambridgeshire and Huntingdonshire.

The technical sales and service department of **Acheson Colloids, Ltd.,** is now at 70, Hill Street, Richmond, Surrey (telephone: Richmond 2066 and 2634). The accounting section will remain at 18, Pall Mall, London, S.W.1.

Clarke, Chapman & Co., Ltd., have opened a branch office at 8, King Street, Manchester, 2 (telephone: Deansgate 4204), under the management of Mr. J. O. Chaloner.

Recording Machine Performance

IN order to allocate costs and plan production programmes, it is necessary to have such information as the time during which a machine is in operation, the reasons for stoppages and the number and type of articles made.

The performance recorder developed by the British Iron and Steel Research Association Engineering Division summarises the operation of the machine and produces a condensed record for analysis. The way in which it works is best described by referring to equipment designed for the specific purpose of recording the operation of a rolling mill. Three operating conditions had to be recorded: running time; idle time (mill stationary during production); and stoppage time (mill out of production).

The recorder has two "accumulators"; one records running time and the other idle time. A clock is arranged to provide electrical impulses at intervals of 3·6 sec. The pulses are automatically sent to either the idle time or running time accumulator.

The operator has under his control a set of push-buttons for recording on the tape the code number of each order or stoppage code number. He also has an "incident button," and when this is pressed the data stored in the accumulators and on the push-buttons are punched in the tape and each accumulator and push-button station is reset to zero.

When an order is received, the operator sets up the order number on the push-buttons. As soon as rolling begins the time pulses are switched automatically from the idle time accumulator to the running time accumulator. When one complete coil has been rolled the mill is stopped. During this period the clock pulses are automatically switched back to the idle time accumulator. When the mill starts rolling again the time pulses are added to those already stored in the running time accumulator.

When the order is completed, the operator presses the "incident" button and both the total time for which the mill was actually rolling and the total idle time are removed from the accumulators and punched in the tape, together with the code number representing the order.

The data on the tapes can be "read" by eye or transcribed on to punched cards either automatically, by means of a tape-to-card convertor, or manually. The analysis can then be performed by punched card equipment. Alternatively, the data on the tape can be printed out by a standard teleprint page printer. If an electronic digital computer is available the fullest analysis of the data and a detailed printed record can be obtained.

An installation to record the operation of eighteen machines has just been manufactured for a steelworks. This installation has a queueing device that makes it possible to record the operation of up to twenty-five machines with a single tape perforator. Both a card punch and a tape punch are to be installed in the accountant's office and they will be connected electrically to the recorders and queueing device to be installed in the production department.

The performance recorder is now being manufactured by the Digital Engineering Co., Ltd., 136, Battersea Park Road, London, S.W.11.

Push-buttons for recording data on machine performance

Fault Classification and Analysis

Reporting Methods and Filing System

By E. H. JESTY, A.M.I.E.E., and J. L. STEWART, B.A., F.S.S.*

A DISTINGUISHED French engineer has said "Every engineering achievement serves to show that the job should not have been done that way"—which is an elegant way of reminding us of the educative value of experience. The design, construction and operation branches of public or private supply can learn much from the objective analysis of system defects. This, however, is one of its aspects where engineering as an exact science tends to become obscured by reporting and classification, which are inherently subjective activities. To obtain the maximum benefit from the records of experiences in this direction it is necessary that a detailed framework should be constructed upon which the whole fault reporting, classifying and analysing organisation may be securely hung.

It seems logical to distinguish between faults which

665/1		665/2		665/3		File Reference
Clandon		Downtown		Uptown		Source
V/R		V/R	c	V/R	d	Voltage Range
M/D		M/D	ii	M/D	iv	Main Division
S/D		S/D	D	S/D	E	Sub-Division
N.I.						Addtl. Note
(Not included)		(11 kV joint failure)		(MV fuse failure)		

Fig. 1.—Suggested form of classification panel

cause interruptions of supply, or operations of relays or fuses, and defective system conditions which, if allowed to persist, might cause interruptions of supply or operations of relays or fuses. In practice, however, such defective system conditions are most often brought to light by routine inspections which are part of normal operating procedure and it is felt by many engineers that they should be excluded from any fault analysis.

A ainst this view may be set the statement that routine discovery of say, corrosion conditions, ought properly to emerge through fault analysis and, perhaps, on the basis of pure logic this question can never be resolved.

Without very clear instructions of the nature and extent of incidents to be reported (and sometimes even with them), considerable differences will arise between the reports from different sources. One has been known to use the fault reporting machinery to report a broken tread on a cast iron staircase, whilst another ceased to furnish reports of a breaker which opened very frequently since the frequent opening came to be regarded as the "normal" condition.

Adequate and accurate reporting is a matter of local education and discipline and the officer ultimately concerned with deducing facts and drawing inferences from records of experience has to assume the prevalence of a high standard of reporting. Next in importance is the classification of the reports and this task is only one degree less subjective than is the reporting. Unless the officer engaged in this work has extensive practical experience, not only of faults but of the idiosyncrasies of officers in the field reporting on them, his classification can be little more than inspired guesswork.

Practical experience, over several years and on a very large scale, has shown the following classification system to disclose valuable information with much less of time-wasting documentation which would be inseparable from a classification which was unnecessarily detailed.

Any and every abnormal occurrence affecting design or operation of systems must be reported to headquarters and the fault reporting machinery provides the most convenient means for doing this. For the purpose of classification and analysis in order to assess the standard of continuity of supply, the highest possible value of which is the aim of every supply undertaking, it may be advisable to adopt a more restricted definition to determine what grist is to be fed to the analytical mill, such as: "An incident which causes no current to flow, or causes current in excess of load current to flow in a circuit."

The obvious first segregation is into voltage ranges, e.g. (a) 66 kV, (b) 33 kV and 22 kV, (c) 11 kV and 6·6 kV, and (d) below 6·6 kV. In some instances it may be desirable further to segregate range (d) into, say, d′ (standard systems) and d″ (non-standard systems) and perhaps even d‴ (direct current systems) but for the moment it will be assumed that information so finely divided would be obtained by separate search as and when required over any chosen period.

Reports are next most appropriately separated into main divisions, e.g. (i) overhead lines, (ii) underground cables, (iii) transformers, (iv) switchgear and control gear, (v) protective gear, and (vi) miscellaneous, with the following supplementary explanations.

Main Divisions

(i) Should include all equipment from end to end of the lines.

(ii) Should include joints and terminations, but not pilot and telephone cables.

(iii) Should include reactors and regulators, also tap changers, but not current or voltage transformers or cable terminations.

(iv) Should include circuit-breakers, switches, isolators, fuses, trip coils, auxiliary switches in circuit-breakers, small wiring to terminal blocks or multicore cables leaving terminal boxes, feeder pillars, supply authority cut-outs, and network link boxes. Should exclude current and voltage transformers and fuses shunting trip coils.

(v) Should include all protective equipment, current and voltage transformers associated with protection, and pilot cables, but not trip coils or auxiliary switches in circuit-breakers.

(vi) Should include current and voltage transformers (associated with metering or purposes other than protection),meters, instruments and alarm equipment.

Several years' experience on a large scale have shown that these main divisions can be conveniently and adequately split up into the sub-divisions shown in Table I.

The machinery for the reporting of faults would

* The authors are with the London Electricity Board.

naturally be subject to variations dependent upon local circumstances, but it is reasonable to expect that a common form of reporting would be adopted throughout one enterprise. Reports, after having been scrutinised by the officer responsible for operations, should be routed at regular intervals, e.g. monthly, to a competent officer for classification. If the suggested system were adopted, every single fault report would be classified into its appropriate voltage range, main division and sub-division or into a separate category (not hitherto mentioned) " Not Included."

The fallibility of human nature makes the last category necessary since a small proportion of reports will come in quite incorrectly prepared in the light of instructions. To reject these and to refer them back to the sender is a tactical psychological error since the result is usually to occasion disgruntlement and to impair the value of future reporting from that particular source. It is wiser to accept them and put them into the N.I. category.

Each report having been classified and " branded " with its appropriate marking, the sorting of them into voltage ranges, main divisions and sub-divisions is quite easily effected. A classification panel should be printed on the official forms, or applied by rubber stamp in the classification office and the panel would appear as shown in Fig. 1.

Punched Card System

With the passage of time, the accumulation of fault reports makes it increasingly tedious to compute rapidly some of the items that are demanded of the fault analyst, especially if the information required is a refinement of the classification suggested above. Even the extension of the classification to cater for more detail does not altogether solve the problem for, however exhaustive the classification, the faults can only be filed in one order at a time—say by date, location or by one item in the classification—and the extraction of faults in a particular sub-class may involve looking at every report in perhaps a dozen files. If the reports have to be removed from the files and subsequently re-filed in their correct order, the time involved may be very considerable.

As an alternative, therefore, to the traditional type of fault report, there is much to be said in favour of some form of hand-punched card system—either as the original on which the fault is reported or compiled subsequently from the original fault report.

Fig. 2 shows the top edge of a hand-punched card designed to cover the classification suggested above, punched to indicate a fault classified c.ii.D. (11 kV cable joint failure). It will be seen that the entire classification

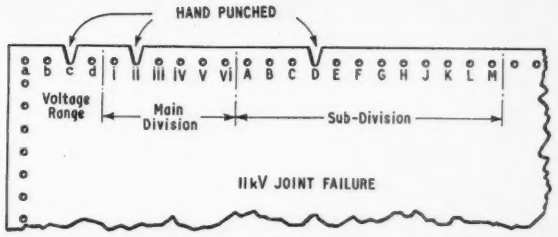


Fig. 2.—Code punched fault classification card

requires only 22 holes. (By using double-punching and a little imagination, the number could be reduced to as few as 12.) On a standard card there would remain about 60 holes for coding additional information such as location, system, number of consumers affected, duration, manufacturer of faulty equipment and so on, and as only 8 holes are required for a numerical code from 1 to 99, the possibilities of this system can be appreciated.

Using such a card as an original report, details of the fault are written on the body of the card, front and back, against headings printed to local requirements. The classifying officer arranges for the appropriate holes to be punched and the cards are put away unsorted. To sort out any particular classification, a needle can be run through the appropriate hole in a bundle of 300–400 cards and a little shake ejects all the cards punched-out at that hole. After use, the selected cards can be replaced anywhere among the other cards since no order is necessary.

To enable an analysis to be made, a statistical summary should be produced at regular intervals, e.g. monthly, and from this it is an advantage to construct a pillargraph which will enable absolute values and trends to be assimilated at a glance. The existence of unsuspected weaknesses emerges as well as the evidence to affirm or deny intuitive " hunches " concerning system defects which design and operating personnel sometimes entertain.

Assessing Significance

It should be borne in mind, however, that even visual assessment, whilst vastly superior to intuition, is suspect on the grounds of its subjectivity. Significance, like beauty, is in the eye of the beholder!

If we could find some numerical value for the degree of significance we should remove much of the personal bias associated with purely visual assessment. This we can do by using the standard statistical tests of significance.

These tests evolve mainly from the following properties of the " normal " frequency distribution: (a) only 5 per cent of the population have values which differ from the

TABLE I

(i) *Overhead Lines*
- A. Lightning
- B. Weather (ice, snow, gales, fog, rain and flood)
- C. Birds
- D. Animals (excluding birds)
- E. Wind-borne material (and objects fouling lines)
- F. Conductors
- G. Binders, clamps, joints and jumpers
- H. Insulators
- J. Line supports
- K. Surges (other than lightning)
- L. Overload
- M. Miscellaneous

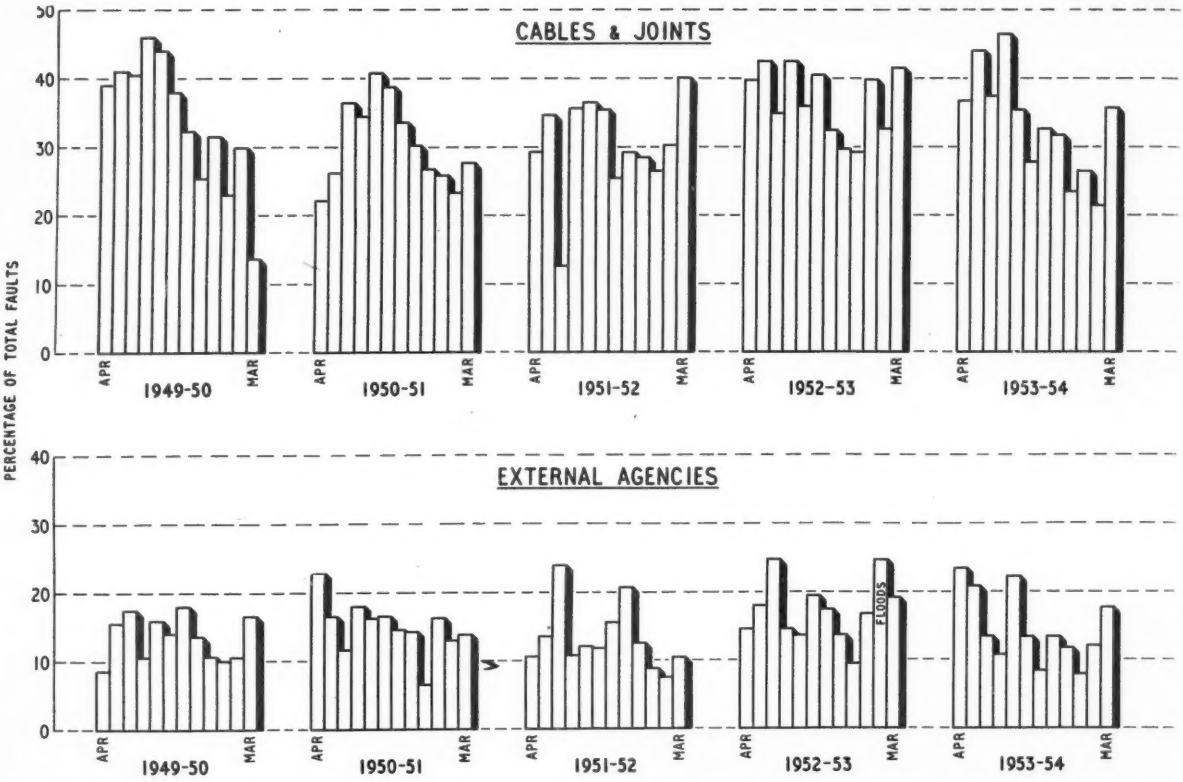
(ii) *Underground Cables*
- A. Mechanical damage (human agency)
- B. Sheath (fracture/corrosion)
- C. Insulation failure (cable)
- D. Joint failure
- E. Termination failure
- F. Oil filled
- G. Gas filled

(iii) *Transformers* (outdoor equipment should be indicated by the suffix " O ")
- A. Insulators/bushings
- B. Windings
- C. Lightning or surge
- D. Tap change mechanisms
- E. Oil (level/quality)
- F. Overload
- G. Connectors/links
- H. Miscellaneous

(iv) *Switchgear and Control Gear*
- A. Mechanical failure
- B. Electrical failure (otherwise normal conditions)
- C. Electrical failure (fault conditions)
- D. Oil defective
- E. Fuse failure (otherwise than shunting trip coils)
- F. Trip coils
- G. Auxiliary switches
- H. Small wiring (other than multicore or relay panel wiring)
- J. Control devices
- K. Miscellaneous

(v) *Protective Gear*
- A. Relay
- B. Panel and multicore wiring
- C. Unsuitable characteristic or incorrect setting
- D. Fuse shunting trip coil
- E. Vibration
- F. Tripping current failure
- G. Current transformer
- H. Voltage transformer
- J. Pilot cables
- K. Rented circuits

(vi) *Miscellaneous*
- A. Bulk supply failure
- B. Utilisation equipment (consumers' installations)
- C. Lack of maintenance
- D. Meters, instruments, instrument transformers and alarm equipment
- E. Suppression coils
- F. Divertor gaps and lightning arrestors
- G. Human accident or error or inadvertent operation
- H. Unknown cause



population mean by more than $\pm 1{\cdot}96\sigma$ and only 1 per cent by more than $\pm 2{\cdot}58\sigma$: (b) if an unlimited number of samples of n individuals be taken from a "normal" population whose mean is $\bar{x}$ and standard deviation σ, the distribution of the sample means will itself be normal with mean $\bar{x}$ and standard deviation (or standard error) $\frac{\sigma}{\sqrt{n}}$: (c) if an unlimited number of pairs of samples of n_1 and n_2 individuals be taken from the same normal population the distribution of the differences between their means will also be normal with mean 0 and standard error $\sigma\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$

It follows that if we had a sample, presumed to come from a given population, and the sample mean $\bar{x}_1$ was such that $|\bar{x}-\bar{x}_1| / (\sigma/\sqrt{n}) < 2{\cdot}58$, we would know that the probability of this happening was less than 1 per cent and we could say that the difference was significant at the 1 per cent level—similarly, with two samples the difference between whose means was such that

$$|o-d| / \left(\sigma\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}\right) < 2{\cdot}58.$$

In practice we rarely know σ and have to derive an estimate (s) by taking the standard deviation of a sample and multiplying it by $\sqrt{\frac{n}{n-1}}$; and as our samples are generally small ($n<30$) this renders necessary some adjustment to the formulæ given in the previous paragraph. Tables, known as Student's t-tables, have been prepared which give effect to this adjustment for various values of $(n-1)$, the number of degrees of freedom.

The following example may serve to illustrate the above technique:

In the six months preceding the introduction of a new operational procedure, the monthly faults recorded in a certain area were—38, 38, 40, 37, 41, 40, averaging 39 per month. In the following six months, 35, 38, 37, 36, 34, 36 faults were recorded, averaging 36 per month. Is this apparent improvement significant?

We proceed to estimate the standard deviation of the population using both our samples:

$$s = \sqrt{\frac{[(-1)^2+(-1)^2+(1)^2+(-2)^2+(2)^2+(1)^2]+[(-1)^2+(2)^2+(1)^2+(0)^2+(-2)^2+(0)^2]}{6+6-2 \text{ (degrees of freedom)}}}$$

$$= \sqrt{\frac{22}{10}} = 1{\cdot}48$$

The standard error of the difference between the means of samples is therefore:

$$s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}} = 1{\cdot}48\sqrt{\frac{1}{6}+\frac{1}{6}} = {\cdot}86$$

$$\text{so } t = \frac{|\bar{x}_1-\bar{x}_2|}{{\cdot}86} = \frac{3}{{\cdot}86} = 3{\cdot}49$$

Entering the t-tables at $\nu=10$ (10 degrees of freedom) we find that values in excess of 3·49 only occur three times in 1,000. We therefore conclude that the difference between the means of the two samples is highly significant.

In the above example we have been dealing with relatively high values which, having a theoretical range of about 40 below the mean, as against ∞ above, might be considered as a skewed distribution. The variation about the mean was, however, so small that the distribution was for all practical purposes normal.

With distributions which are markedly skewed, such as would arise in the case of a particular type of fault which occurred on average less than once a month, the use of the standard deviation as a guide to significance is not

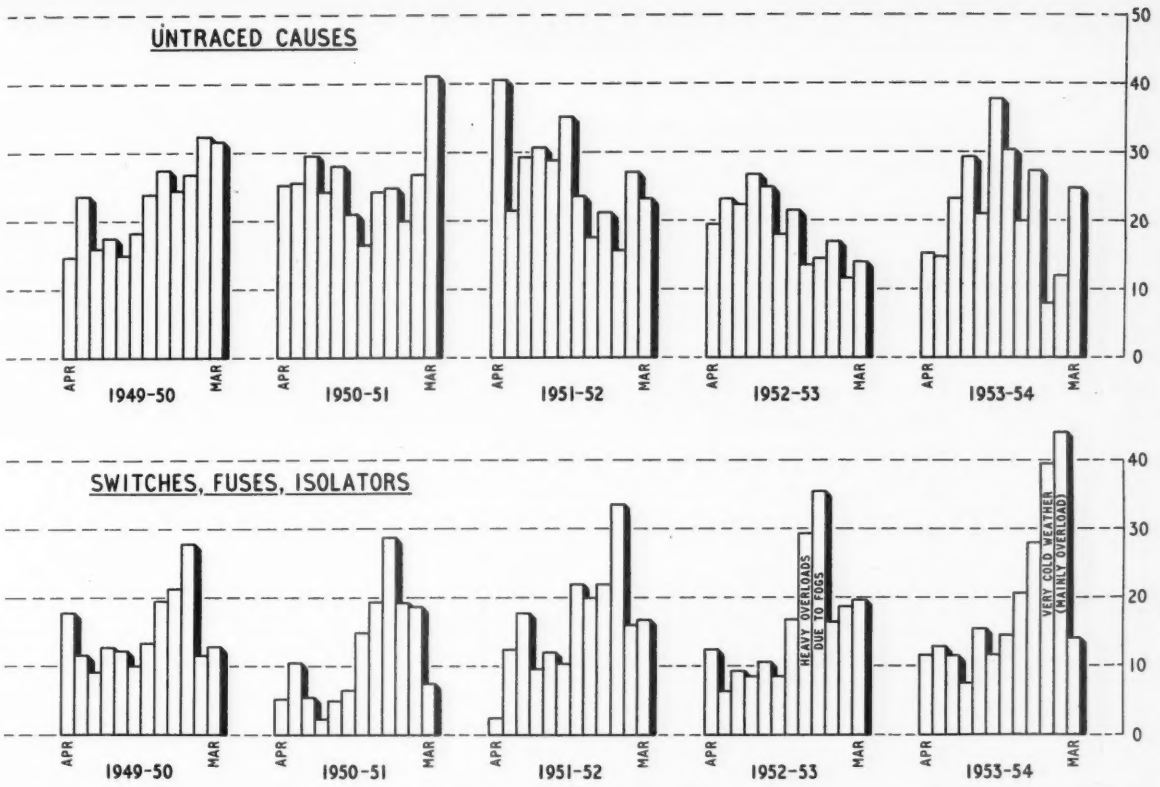


Fig. 3.—Pillargraph of a fault analysis, showing the percentage of total faults ascribed to various causes

practicable. It can easily be shown that the probability curve for this type of occurrence is of the form

$e^{-m}(1+m+\frac{m^2}{2!}+\frac{m^3}{3!}\ldots)$, known as the Poisson distribution, where m = the average frequency and the successiveterms give the probability of 0, 1, 2 . . . . . occurrences.

Suppose, for instance, that over the past two years a certain fault had an average frequency of ·5 per month.

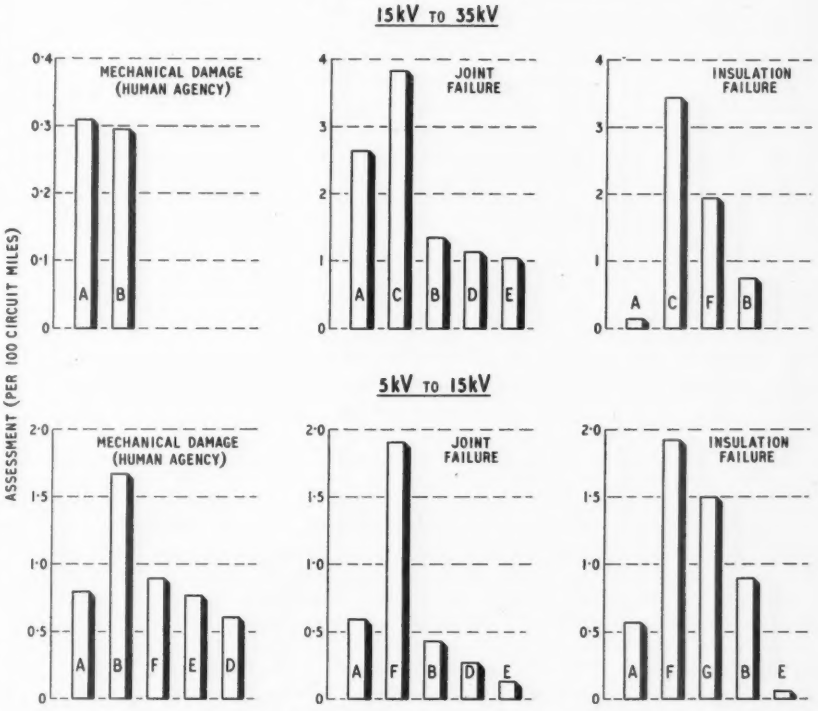
Substituting m = ·5, we have

$$\cdot 6065\left[1+\cdot 5+\frac{(\cdot 5)^2}{2}+\frac{(\cdot 5)^3}{6}+\frac{(\cdot 5)^4}{24}\ldots\ldots\right]$$
$$=\cdot 6065+\cdot 3032+\cdot 0758+\cdot 0126+\cdot 0016\ldots\ldots$$

From this we see that the probability of 3 such failures occurring in a month is 1·26 per cent and of 4, ·16 per cent. If 3 of these failures should occur we would consider this significant (at the 5 per cent, but not at the 1 per cent level) and 4 failures would be highly significant.

It may be of interest to point out that, as the value of m in the above series increases, the distribution rapidly

Fig. 4.—Comparative assessments of cable fault classification in different systems for the year 1951–2. (A, B, C, etc., represent different districts)



approaches the " normal " curve—in fact, for values of m above 6 it can be considered normal.

Throughout these notes on significance we have considered only discrete values, i.e. actual numbers of faults. With systems which are changing in size so that actual numbers may be misleading, it will be more satisfactory to use relative values, e.g. assessments as indicated below, of faults per 100 miles of cable. In this event, the resultant values may be so low as to appear suitable for treatment by the Poisson distribution. The Poisson treatment should only be applied when the actual numbers are very low and the distribution skewed. It will be appreciated that the reduction of the ordinates of a normal distribution by the introduction of values resulting from the basis of assessment employed has no effect on its normality.

Fig. 3 shows a pillargraph of a fault analysis. Absolute values and percentages mean little unless it is easily comprehended to what magnitude of enterprise they refer. It is instructive, therefore, to determine a basis of assessment on which to make comparison between different periods and the performance of the several items of equipment. For lines and cables a suitable basis may be " per 100 circuit miles in each voltage range " and for transformers, " per 100 transformers having primary voltages in each voltage range."

A general assessment applicable to Category iv, switchgear and control gear, is more difficult to decide, since the group embraces a wide range of equipment and an assessment of " per 100 switches or circuit-breakers " would be meaningless.

For such a category assessment should not be made as a routine operation but if abnormal numbers of failures emerge in any particular type sub-division, an assessment on a relevant basis for that particular failure might be made over a few periods to determine if any significant trend could be detected.

Some comparative assessments of some different systems for the year 1951–52 are shown in Fig. 4. The practical value of intelligent and consistent fault analysis is evident from the information contained in the chairman's address to the I.E.E. Scottish Sub-Centre in 1954.* On 2,747 miles of h.v. cable in service, he gave assessments of: (6·6 kV) 1·12: (11 kV) 8·04: (20/25 kV) 3·09 faults per 100 circuit miles per annum.

Causes were evenly divided between insulation failures, joints and end boxes, with lightning, subsidence and electrolysis as secondary causes. On 6,000 miles of l.v. cables the assessment was 7·1 per 100 miles per annum.

" The fault incidence on old cables during the last six years (many of the 6·6 kV cables had been in service for 50 years) has been generally better than that of cables laid during the last 15 years . . . it is not yet possible to predict the economic life of h.v. underground cables." The chairman could not have made these statements with confidence without a sound system of fault reporting, classification and analysis.

In conclusion, the authors thank Mr. L. H. Welch, B.Sc., M.I.E.E., Chief Engineer of the London Electricity Board, for permission to publish this article.

*R. J. Rennie. *Proc. I.E.E.*, Vol. 102, Pt. A, No. 1: (Feb., 1955). " The Performance of Distribution Equipment in Service."

Measuring Current at High Voltages

AT a meeting of the Institution of Electrical Engineers' Measurement and Control Section on 16th April, Messrs. M. Kaufmann and M. Waters and Dr. A. J. King discussed the measurement of current in high-voltage circuits without orthodox current transformers. The most important effect of high transmission voltages in this respect, both economically and in regard to transmission station design, was stated by Mr. Kaufmann as the advent of the air-blast circuit-breaker, which prevented the use of terminal bushings as insulated primary conductors.

To obviate both difficulties in air-blast and some types of low-oil-content installations, current transformers were provided on one side only of a breaker. This method served for measurement but not for protection, since it resulted in the loss of the fine dividing line between busbar zone and circuit zone as well as freedom from intertripping complications, which characterised bulk-oil installations with bushing-type current transformers. For protection the ideal was to have current transformers on both sides close to the busbar contacts. With fault levels of 12,500 MVA or more, faithful reproduction of the first half-cycle of fault current was necessary and accuracy should be not worse than that given in B.S. 2046.

Mr. Waters advocated the avoidance of expensive major insulation of a current transformer by putting the current-measuring device on the conductor and by transmitting signals indicating magnitude and phase of the current to a receiver at earth potential. The E.R.A. had considered three schemes, the simplest being an insulated tube inside which sound waves at 50 c/s were transmitted. This, however, was subject to temperature effects and had its own transient response which would rule it out for protective gear, but schemes based on modulated beams of light or radio signals would be quite feasible.

Any method of indication or protection should be based on overall performance without reference to standard secondary voltages or currents. Sometimes symmetrical components could be isolated for protective purposes in the signal stage and any considerable power was needed only for tripping or control. Another device was the relatively inexpensive air-cored toroid, which had a small output compared with that of a current transformer but gave a performance that could be calculated exactly.

Dr. King described a method which employed an electro-mechanical permanent-magnet transducer at the h.v. overhead line coupled by an insulating rod or tube to a mechanical-electrical transducer on the ground. The moving coil at the h.v. end would be fed from a live current transformer with only nominal insulation and that at the l.v. end would feed a valve amplifier. Torsional transmission was less likely than longitudinal transmission to be influenced by vibration due to operation of nearby switches; in both cases eddy-current damping in the oscillatory system counteracted transients at its normal frequency. Only about 1 millisec was taken to transmit an oscillation down a 10ft insulating tube and output was 70 deg in phase behind input. For torsional transmission a moving magnet transducer had been developed which needed no current transformer; overloads of fifteen times full-load were accommodated linearly and the output voltage could be applied to measuring instruments and relays with negligible phase error.

Engineering in Europe

ABSTRACTS FROM FOREIGN TECHNICAL JOURNALS

THE disturbed movement of the rotor of a synchronous generator the excitation of which is controlled according to the derivative of the swing has the character of a simple oscillation determined by one pair of complex roots, despite the high order of the equation representing it. These roots can be found easily by the iteration method or graphically from the frequency relations. Use of the principle of superposition of powers yields simple theoretical relations for the calculation of damping and synchronising torques set up by the regulation and the rotor circuits, so that the effect of the individual factors on the oscillation process can be quantitatively assessed and its parameters can be correctly chosen in the project stage.

When the frequency of the oscillation process has been predetermined, the analysis of the process can be based on a vector diagram enabling the phase relations of the main parameters in all the elements of the regulation circuit to be found. The problem of synthesis can also be solved, viz. the determination of the parameters of the exciter circuit and damper winding required to obtain a chosen damping factor. The variation of the stator current is represented by an elliptic spiral in the vector diagram in the (d, p) plane. The damper winding has little effect on the oscillation process; large damping factors can be obtained by an automatic regulation of the excitation based on the derivatives of $\Delta\Theta$, where the dynamic characteristics of the excitation system need not be of a very high order.—" Analysis of the Power Swing of a Synchronous Machine, Considering the Regulation of the Excitation," I. D. Urusov, *Izv. Akad. Nauk, Otdel. tekh. Nauk,* No. 10, pp. 77-89, 1956, in Russian.

Capacitor Switching

Switching tests on banks of parallel capacitors were carried out with air-blast circuit-breakers, small oil-volume breakers with and without an additional supply of quenching medium, and with special capacitor switches with and without series resistances. The systems had only one capacitor installation. On switching-in, no current peaks dangerous to capacitors and switchgear were observed, even without protective series resistances in circuit. Circuit-breakers with a supply of quenching medium independent of the current usually disconnected the capacitor banks without re-ignition and voltage surges, whereas the breaker types with self-generated gas blast had a stronger tendency to re-ignite and, therefore, to produce surges. Series resistances always damped the severity of the transient phenomena both on circuit-making and breaking.

In the case of a capacitor installation connected to the system by a fairly long cable line the transient processes were aggravated by the cable and the voltage surges in the system thereby reinforced. Earthing (voltage) transformers connected to the battery terminals were found to have a very unfavourable effect on the circuit-breaking phenomena, which can be explained theoretically by the fact that they form oscillation circuits with the capacitances to earth. V-connected voltage transformers for discharging the batteries are more suitable, the switching phenomena being roughly the same with or without them.—" Switching Shunt Capacitors in Power Systems," J. Buter, *E.T.Z.(A)*, Vol. 78, No. 1, pp. 12-19, 1st January, 1957, in German.

Readers who require accurate full translations of any of the articles abstracted in this section can be put into touch with the translators who will supply them at current rates.—Editors, *Electrical Review.*

A.C. Arc Calculations

In the author's opinion, the most satisfactory type of differential equation of the electric arc so far suggested is that published by O. Mayr in 1943, not least because it lends itself to necessary modifications and improvements widening the range of its possible application. It has, in fact, almost the character of a fundamental relation into which ever more refined expressions for the main parameters, such as the power dissipated and heat altering the resistance of unit length of the arc by a certain factor, may be introduced to bring the theoretical results into ever better agreement with experimental findings. In this way the author supplements Mayr's work and evolves a theoretical method of his own, removing some limitations of Mayr's original method. Yet he does not claim that his equation is generally valid or, indeed, that the possibility of deriving a generally valid equation has been established at all.

The equation presented, and applied in the paper to the solution of most important problems of circuit-breaker theory, holds good for arcs with prevalently thermal ionisation ($T \geqslant 3{,}000$ deg K). It describes the arcing and extinction process of an arc in a 6 kV cross-jet oil circuit-breaker in the range of breaking currents from 330 A to 7,650 A in good agreement with experimental facts. The theoretical values of residual arc resistances and post-arc currents also agree with experimental results obtained by a number of authors in comparable cases. It is thought that the method may also be successfully applied to circuit-breaking arcs in 35 kV oil circuit-breakers. Where oil and air-blast breakers for higher voltages are concerned, the method will probably be useful only in the case of heavy breaking currents.—" Calculation of the A.C. Arc," I. S. Taev, *Elektrichestvo,* No. 10, pp. 57-61, 1956, in Russian.

Industrial Distribution Systems

Three-phase l.v. distribution systems with isolated neutral are commonly used for the supply of industrial plants and mines, mostly at a line voltage of 500 V. This method of distribution has economic advantages and is also satisfactory from the safety aspect, provided it is correctly designed and carefully earthed. Since earthing conditions and state of the insulation are liable to vary, they must be permanently supervised and special relays have been designed and introduced for this purpose. To determine the contact voltages and thus the risks incurred by the personnel, it is necessary to know the voltages to earth of the phase conductors, frames and neutral points of the electrical equipment under various conditions of the insulation and during unavoidable variations of the capacitance of the system and of the earth resistances.

The author presents a relatively simple method of determining the voltages to earth and earth currents,

based on admittances. This is first applied to an idealised system in which the phase-earth conductances and susceptances are equal, and then to the general case corresponding to actual systems in which they are, as a rule, unequal. Then the contact voltages are determined analytically and by a simplified graphical method. The numerical examples worked are based on assumptions of deterioration of the insulation and of the earthing conditions and show that even unsatisfactory earthing considerably reduces the dangerous contact voltages.—" Voltage to Earth and Earth Currents in Industrial Distribution Systems with Isolated Neutral," J. Cenek, *Elektrotech. Obzor*, Vol. 46, No. 1, pp. 18-22, 1957, in Czech.

Busbar Joints

The permissible contact resistance of busbar joints or similar arrangements under a high contact pressure is greatly influenced by mechanical deformations of the bearing contact areas. The electrical conduction from metal to metal takes place in cracks in surface films opened by mechanical deformations. The corrosive effect on copper in atmospheres containing sulphur is greatly increased by moisture in the air, hence obvious preventives of corrosion are exclusion of fresh air and drying the air in the room. Another method of protection is to coat the copper with other metals; chromium and nickel possess good corrosion resistance, though they are inferior electrically to silver and tin because of their hardness. The mechanical characteristics of the protective metal itself and of its oxide films and the electrical conductivity of the protective metal determine the actual contact resistance.

The experimental results presented by the author prove that protective galvanic coatings harder than the base metal, e.g. silver on copper, should preferably be thin (5 μ) rather than thick (20 μ or 40 μ), that nickel and chromium are unsuitable because of their hardness and unsatisfactory electrical characteristics. Tin coating deposited by the dipping process is satisfactory because it is soft. The onset of corrosion is considerably delayed by greasing the contact areas, although this has to be taken in the electrical sense only (because *visible* corrosion is not postponed).—"Large-Area Contacts under High Pressure in Corrosive Atmospheres," D. Müller-Hillebrand, *E.T.Z.(A)*, Vol. 77, No. 23, pp. 860-863, 1st December, 1956, in German.

Transformer Oil Testing

It has been found that the usual physico-chemical testing methods of transformer oils, viz. determination of sludge content, components insoluble in standard petroleum/ether, acid and saponification numbers, are insufficient for assessing the character of the ageing processes during long service periods of the order of twenty to thirty years. Investigations on transformer oils which have been in service for up to 16 years indicated a wholly satisfactory condition of these oils, while measurements of loss factor showed a rapid increase to high values. Ultra-red spectroscopy furnished an explanation of this phenomenon, viz. the presence of primary polar ageing products (ketones and aldehydes), which is not revealed by chemical analysis.

Investigations on the ageing of fuller board steeped in oil showed that its dielectric losses rise at a considerably slower rate than those of the oil itself. The deterioration of the dielectric loss factor of the oil can be partly reversed by elimination of the ageing products by treatment with fuller's earth. The use of inhibited oils enables the whole ageing process to be slowed down. The authors recommend that the conventional and routine tests carried out on samples of transformer oil taken after considerable service periods should be supplemented by measurements of the loss factors and ultra-red spectrum analysis of the oil. This enables the recorded and graphed results to be combined to supply ageing diagrams of the oil.—" Investigations on Used Oils taken from Travelling 220 kV Transformers," L. Maurer and T. Wörner, *E.T.Z.(A)*, Vol. 77, No. 24, pp. 885-888, 11th December, 1956, in German.

Plastic-Insulated Cables

The development of plastic-covered cables for power transmission is, for obvious reasons, a rather delicate and relatively slow process and it would probably be premature to think that their general introduction is imminent. However, the fact that such cables have been used for 15 kV lines since 1953, according to the author, proves that their intrinsic characteristics are satisfactory for the purpose and that their range of application is likely to be extended.

As a representative of the cable industry, the author is in a position to describe production processes of p.v.c. and polyethylene-covered cables, based on the extrusion principle, the details of the cable design, performance characteristics and testing methods applied to ascertain them, and the very important simplification of the cable joints, sealing ends and other fittings rendered possible by the use of the new materials. The descriptions are supported by test results obtained in the Fontenay laboratory of Electricité de France and supplemented by economic considerations showing that the new type of cable is definitely competitive with the conventional types. —" Use of Thermoplastic Insulating Materials in the Production of Medium-Voltage Cables and their Fittings," C. A. Flamand, *Bull. Soc. Franc. Elect.*, 7th Ser., Vol. 7, No. 73, pp. 40-50, January, 1957, in French.

Spark Erosion of Metals

According to the accepted and demonstrable theory of the spark erosion of metals the optimum relation between duration of a current pulse and volume of material eroded is based on a balance between the heat produced by ion bombardment of the cathode and electron bombardment of the anode, and the rate of heat propagation in the metal, respectively. If the pulses are of short duration, the rate of supply of the localised heat source, or hearth, on the metal (which is concentrated in a point) exceeds the rate of removal of the heat from this " point source " considerably. Accordingly, the volume of metal heated to melting point remains very small, despite the accumulation of heat at that point. With increasing pulse duration the conditions improve up to an optimum ratio (=maximum volume of metal melted), after which the erosion rate falls again, since the heat produced is then dissipated too widely and the temperature of the " source " falls below melting point.

The investigation presented determines experimentally the functional relation between pulse duration and volume of metal eroded via the energy liberated in a pulse. The pulses were set up by a " long line " with concentrated parameters and the energy liberated was measured by a calorimeter of a special type enclosing the spark gap (actually only the energy liberated in 10,000 pulses was fairly accurately measurable). The curves of the erosion factors for the electrode pairs steel-brass and copper-copper show maxima for pulse durations of 350-500 μsec (anode) and 100-320 μsec (cathode), and 100-140 μsec, respectively. —" Effect of the Duration of a Pulse on the Electric Erosion of Metals," B. N. Zolotikh, *Elektrichestvo*, No. 8, pp. 55-57, 1956, in Russian.

Electrical Expansion in Brazil

BY OUR RIO DE JANEIRO CORRESPONDENT

THE Brazilian Institute of Economy, in a recent bulletin, has published an analysis of the 1955 reports of the principal electricity supply groups holding concessions in Brazil. Power production increased by 15 per cent between 1953 and 1954 and by 5 per cent between 1954 and 1955. To the 1955 total of 9,845 million kWh Brazilian Traction contributed 6,945 million and Empresas Electricas Brasileiras 1,779 million.

The capital invested in these two companies and in Central Electrica de Rio Claro and Centrais Electricas de Minas Gerais increased by 13 per cent between 1954 and 1955 to 25,627 million cruzeiros. This was largely accounted for by heavy investments of Empresas Electricas (930 million crs.) and CEMIG (1,755 million crs.). Of the additional capital employed in 1955, 35·3 per cent was derived from new capital issues, 18·5 per cent from re-investments of profits and 46·2 per cent from loans. [The sterling free market rate for cruzeiros is about 180 to the £.]

Between 1954 and 1955 the percentage of profits on paid-up capital dropped from 10·7 to 10 in Brazilian Traction, 3 to 2 in C. E. de Rio Claro and 2·6 to 2·4 in independent companies. The percentage increased from 12·3 to 13·7 in Empresas Electricas and from 1·4 to 4·9 in CEMIG. Brazilian Traction and C. E. de Rio Claro paid no dividends in 1954 or 1955, but retained all profits for re-investment. In the same years dividends distributed by Empresas Electricas increased from 8·8 to 15·1 per cent and those paid by CEMIG, from 1·3 to 2·6 per cent. In the independents the 1954 dividend of 1·4 per cent was maintained in 1955.

The president of the Light & Power group of companies, after a visit to England and Switzerland to raise capital, said that within the next four years his companies would increase their plant capacity by 500 MW.

New Foreign Investments

In 1956 Brazil issued 235 licences to import, without exchange cover, machinery and equipment valued at U.S.$85·8 million for establishing new industries or extending existing installations. The value of such imports is registered as foreign investment capital, entitled to specific privileges as regards repayment of capital and remittance of profits. The principal contributing countries were: U.S.A. $35·9 million, Western Germany $25·5 million, the U.K. $7·9 million, France $5·6 million, and Italy $2·6 million. During the last quarter of 1956 the value of these imports amounted to $28·3 million.

The Emerson Co. of the U.S.A., in association with Industrias Reunidas Max Wolfsan, has inaugurated a factory at Rio de Janeiro, and is building another at Belo Horizonte, to produce electronic apparatus for television and broadcasting.

Under the Brazil-U.S.A. agreement of November, 1956, Brazil will receive American surplus agricultural produce valued at U.S.$138 million, to be paid for in cruzeiros, and 85 per cent of the amount will be treated as a loan to finance basic development projects. It is stated that these will include the Tres Marias hydro-electric project in the Sao Francisco basin, the Peixoto project and that of Furnas, in the Rio Grande valley.

Brazilian Traction, Empresas Electricas, the mixed hydro-electric companies of Minas Gerais and Sao Paulo, as well as several independent companies, will participate in the Furnas scheme. The project provides for a 1,500 MW power station to be completed in stages of 100 MW each, and a dam at Furnas on the Rio Grande between Minas Gerais and Sao Paulo. The station will be about equidistant from Rio, Sao Paulo and Belo Horizonte and will supply power to the Central-South region, embracing the States of Minas Gerais, Rio and Sao Paulo, southern Espirito Santo, the Federal District and North Parana. It will benefit 500 municipalities and some 20 million inhabitants. The dam, 10 metres high and 500 metres long, to be completed by 1960, will form an artificial lake covering 579 square miles and cost 25,000 million crs. This sum will be subscribed mainly by the Treasury, the States of Minas Gerais and Sao Paulo, CEMIG and the Sao Paulo Light & Power.

A mixed-economy society, the Central Electrica de Furnas, is being organised. The Union will retain 51 per cent of the shares, private companies holding 25 per cent, but without the right to vote. The Union's shares will be paid for out of the proceeds of the Federal Electrification Fund.

For the building of the Tres Marias dam (see *Electrical Review*, 13th July, 1956) the project presented by a consortium of American firms is meeting with most favour. The consortium includes Brown & Root, Texas, the Utah Construction Co., the Raymond Concrete Pile Co., Kaiser Engineers and Morrison Knudsen. The work is to be completed by 31st December, 1960. No details have as yet been announced. Among other tenderers were Taylor Woodrow, of London, and an association of Swiss contractors.

The Export-Import Bank has approved a loan of U.S.$12 million to CEMIG to raise the capacity of the hydro-electric station at Itutinga on the Rio Grande, between Lavras and Sao Joao del Rei, and build a reservoir at Camargos. The capacity of the station will be increased to 250,000 h.p. in two stages of 25,000 h.p. each. A 38,000 h.p. plant at the foot of the dam will permit remote control. The reservoir, holding 600 million litres, will benefit the Rio Grande chain of power stations, including Itutinga and Peixoto, already built, and those of Funil, Sao Miguel and Maribondo, to be constructed.

Sao Paulo Projects

The French group, Neyrat-Reylier et Picard, has signed an 18 million franc contract with the Sao Paulo Government for studies and project in connection with the utilisation of the hydraulic potential of the Tiete River. The Barra Bonita station, now being built on the Tiete, is estimated to cost 500 million crs. and should start operating in 1960. A dam, 500 metres long and 33 high, will be built permitting storage of 2,720 million cu m to feed the projected chain of power plants.

Sao Paulo has called for tenders for two 20 MW thermal electric stations to be built, one at Votuporanga, the other at Florida Paulista.

The State Governor announces that work will start in June next at Urubupunga, where 1,000,000 h.p. is

available. The Brazilian Development Bank has advanced 14,400,000 cruzeiros to the Companhia Prada de Electricidade to finance 60 per cent of the cost of building a diesel station adjoining the company's hydro-electric plant on the River Uberlandia.

The first two 40 MW units at the Peixoto station have been inaugurated and the capacity is to be raised to 440 MW by installing six more turbines. In addition, Cia. Paulista de Forca e Luz announces that it will carry out the Praia, Marimbombo and Estreito projects at a total cost of 2,400 million crs., or 6,000 crs. per installed kW.

Sao Francisco Expansion

President Kubitscheck has approved the 1957-60 development plans of Companhia Hidrelectrica de Sao Francisco (CHESF). The cost is estimated at U.S.$15 million, advanced by the Export-Import Bank, and 1,650 million crs. in local currency. A second underground power house will be built and a 60 MW generator, the first of six to be installed, will start operating in 1959. New transmission lines are planned for completion in 1960. The cost will be met from CHESF's own funds (50 million crs.), re-investment of reserves (800 million crs.), a loan from the Brazilian Development Bank (500 million crs.) and a federal grant out of the proceeds of the Electrification Fund.

The primary transmission system will include a double line to Recife, with two substations, augmentation of the Recife and Salvador power supplies, with complementary installations and connections to the Cotegipe station. The capacity of the latter is to be raised to 286 MW in 1962.

The Valle de Sao Francisco Commission has been authorised to co-operate with the Minas Gerais Government in increasing the capacity of the Montes Claros hydro-electric system. A definite project is being drawn up by Centrais Electricas de Minas Gerais.

Third Party Actions

Shifting Liability for Damages

By F. E. SUGDEN

ELECTRICAL contractors are called upon to install all kinds of electrical equipment which they have not themselves manufactured. If any of this equipment gives trouble because of a fault in its manufacture the customer is likely to hold the electrical contractor responsible for the defect. In all probability he will not claim against the manufacturer of the faulty article but against the electrical contractor, who is not to blame. The question naturally asked by the contractor is what he shall do in the matter.

The answer is that he should defend himself through the medium of a " third party action "; that is, he should apply to the High Court for an Order joining the manufacturer of the faulty article as defendant in the action brought by the disgruntled customer. The effect of this procedure is that whatever damages, including the costs of the action, are claimed against the contractor the amount must be met directly by the manufacturer.

To illustrate this theme I quote a case which came before the Court of Appeal recently. There was a written contract between the occupiers of a factory and the main contractors for the execution of building work at the factory which provided that the contractors should indemnify the occupiers " against every claim (against the occupiers) under any Statute or at Common Law . . . (*b*) death . . . arising out of or in connection with the carrying out of the contractor's work and from any cause other than negligence of the occupiers or their employees."

An employee of sub-contractors, who was an experienced electrician, was working on a switch panel 2ft wide. He was removing nuts from the panel at a height of 3ft 5in above floor level. The panel was disconnected but close to it were two other panels which were not disconnected and carried bare conductors so exposed that they might be touched. These panels were in a contactor room which was a place set apart, to which only authorised persons were allowed access in accordance with Regulation 15 of the Regulations for the Generation, etc., of Electrical Energy, 1908. (Regulation 15 requires that every such switchboard " shall, if not located in an area or areas set apart for the purposes thereof, where necessary be suitably placed or enclosed. No person except an authorised person, or a person acting under his immediate supervision, shall for the purpose of carrying out his duties have access to any part of an area so set apart.")

While at this work the employee came into contact with one of the bare conductors and was killed. No portable insulating screens were provided or used although under Regulation 24 such screens should have been provided. (Regulation 24 says that " Portable insulating stands, screens, boots, gloves or other suitable means shall be provided and used when necessary adequately to prevent danger, and shall be periodically examined by an authorised person.")

The relatives of the deceased man claimed damages against the occupiers for breach of statutory duty under Regulation 24. The occupiers denied liability and claimed indemnity, if they were held liable, from the main contractors under the indemnity clause mentioned earlier.

The Court of Appeal held, *inter alia*, that the occupiers were entitled to be indemnified by the contractors against liability for breach of statutory duty, because what was excepted from the indemnity clause by the word " negligence " in the passage " any cause other than the negligence of . . ." meant negligence in the ordinary sense. The word " negligence " in that context did not include breach of statutory duty.

In this case the widow of the deceased man successfully claimed against the owner of the factory who, in turn, obtained an Order from the Court of Appeal at the end of the judicial proceedings that the damages awarded to the widow and the cost of the action should be paid by the contractor and not by the occupier of the factory.

I quote this case so that the electrical contractor who is faced with a similar predicament, only in a reverse position to the case I have quoted, should adopt the same procedure. A contractor against whom a claim is successfully made may apply to the High Court for the manufacturer of a faulty article to be joined as a third party. In this way if damages are successfully claimed against the contractor they are automatically transferred to the manufacturer without any financial liability whatsoever to the contractor.

Power Rectifiers

A Review of Static Methods of Current Conversion

By M. H. TOVEY, B.Sc., A.M.I.E.E.*

THE adoption of alternating current for distribution of electrical power has brought with it an increased demand for conversion equipment for those applications where direct current either provides operating advantages or is indispensable. No a.c. motor has as yet been designed having torque and speed regulation characteristics which compare favourably with those of the d.c. motor while expansion of electro-chemical processes grows apace and there are few cases where the means of converting a.c. to d.c. cannot be achieved by means of a static rectifier of one form or another. This article describes the forms of static rectifier used in the power field. The principal types are metal rectifiers, valve type rectifiers (in the lower power range), mercury pool type rectifiers, and semi-conductor rectifiers.

Of these types metal rectifiers and mercury pool type rectifiers have so far been used the more extensively each in a fairly defined field determined largely by the d.c. operating voltage required—this for the reason which will be apparent as we consider the voltage lost in the rectifying device.

Metal Rectifiers

Perhaps the most attractive feature of the metal rectifier is its simplicity and the entire absence of ancillary apparatus. Where the a.c. supply voltage is sufficiently near the d.c. voltage required and the exact value of the latter is not important a stack of plates is all that is necessary. Where a transformer is necessary to obtain the required d.c. voltage it can be of a simple construction without special windings.

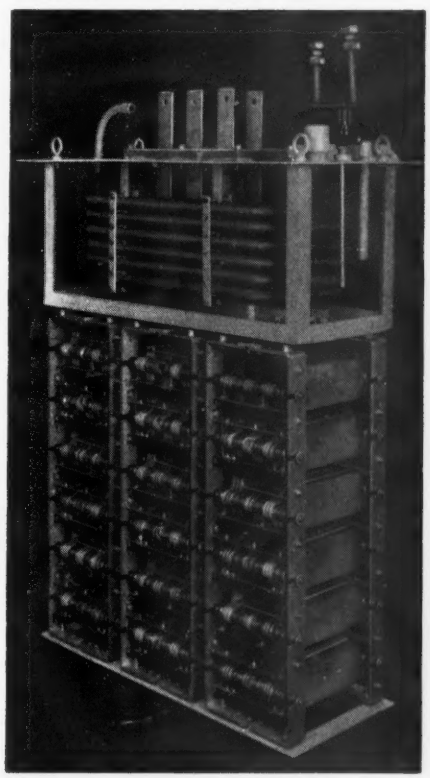


Fig. 1.—Interior of 18 V 1,000 A water-cooled selenium rectifier (Electric Construction Co.)

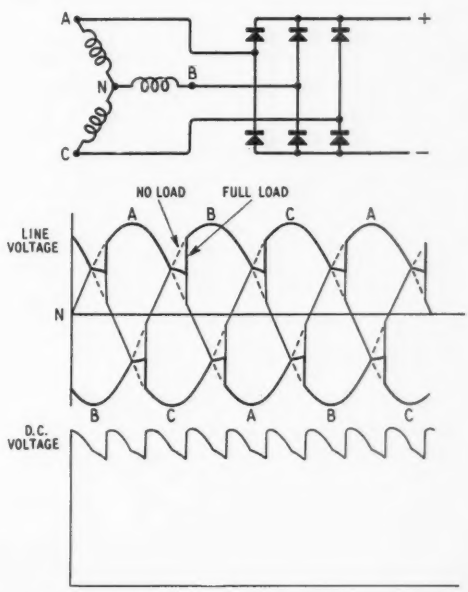


Fig. 2.—Voltage waveform of a three-phase bridge rectifier

Selenium metal rectifier plates are smaller and more efficient than copper oxide rectifier plates, the latter being now largely superseded, except for special instrument work. Single rectifier plates are manufactured in a range of sizes from a fraction of an ampere to 20 A or more. By the use of plates and equipments in parallel virtually any desired current can be obtained. Selenium rectifier plates in an oil-immersed water-cooled assembly for an output of 1,000 A at 18 V are shown in Fig. 1.

The voltage which can be handled by a single metal plate is limited and plates must be used in series to deal with higher voltages. Plates can be graded, reserving the best for use on higher voltages and so reducing the number in series, but a d.c. working voltage per plate somewhat less than 20 is frequently used.

For power work the most common connection of plates used is the three-phase bridge connection shown in Fig. 2.

The current flows to the positive d.c. connection from whichever terminal of the transformer secondary winding is most positive at the time and back from the negative d.c. connection into whichever terminal is most negative. Thus the outgoing d.c. flows in turn through the top three rectifier units, each for one-third of a cycle, and back through the bottom three, each for one-third of a cycle. The d.c. positive thus has a potential of whichever terminal A, B or C is the most positive and the d.c. negative has

* B.T.H. Plant Contracts Department.

a potential of whichever is the most negative. The d.c. voltage is thus the difference between the two thickened lines and is shown in the second curve. It has a ripple of about 6 per cent at a frequency of six times the supply frequency.

For just over one-third of each cycle each unit carries forward current; for the remainder it is subject to a reverse voltage having a peak value equal to the peak d.c. voltage. The total current output of the bridge is therefore three times that of the individual units.

It will be noted that the voltage lost is due to that of the number of plates in two arms of the bridge in series and consequently for heavy current low voltage applications —such as electro-plating—it is an advantage for the transformer secondary to be connected diametric as shown in Fig. 3. With this connection the ripple in the d.c. voltage output is also about 6 per cent.

It will have been noted that for higher voltage working plates must be connected in series and consequently the voltage lost in rectification becomes progressively higher as more plates become necessary. A point is therefore reached when the voltage lost exceeds that of a mercury-arc and at that voltage the mercury-arc may also prove cheaper in first cost. A single arc has been used successfully to rectify as high as 20 kV.

Special designs of mercury-arc rectifiers may have an arc drop as low as 10 V but in most the arc drop will be around 20 V or more.

It is therefore only possible to indicate that the cross-over in efficiency as between metal plate rectifiers and mercury-arc rectifiers is not likely to be lower than 100 or greater than 200 and we shall therefore expect to find the majority of the applications employing metal rectifiers having output voltages below 200, although there will be exceptions, notably, the use of metal rectifiers for very small currents at high voltages.

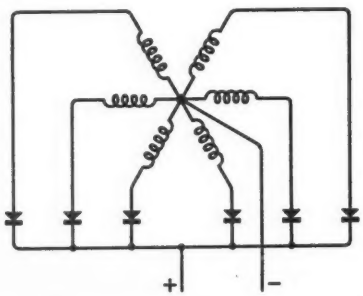


Fig. 3.—Diametric connection for l.v. heavy current metal rectifier

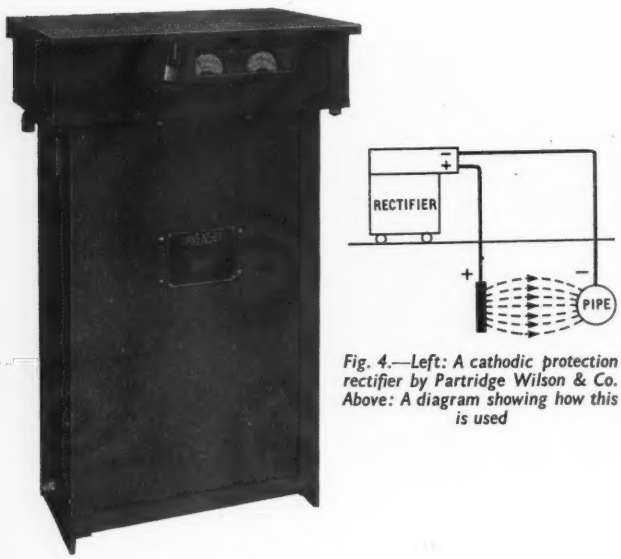


Fig. 4.—Left: A cathodic protection rectifier by Partridge Wilson & Co. Above: A diagram showing how this is used

An example of metal rectifier application is an 80 kV 300 mA oil-immersed selenium unit for use in conjunction with a precipitator equipment. A three-phase bridge connected rectifier is housed in the same tank as its transformer which also contains an earthing switch interlocked with the control cubicle door and the precipitator chamber. The control cubicle contains an induction regulator under the control of a contact ammeter, so that the current can be maintained constant, as well as the usual instruments and control switches.

Another interesting application of metal rectifiers is their use for cathodic protection. Fig. 4 shows a self-contained equipment designed for operation outdoors, the components comprising transformer, metal rectifier, etc. Corrosion is prevented if current from rectifiers installed at intervals along the pipeline flows into the pipeline along its whole length.

Among other applications for which metal rectifiers are used can be mentioned general supply purposes, excitation supplies, battery charging, engine starting, cinema projection arcs, supply for electro-chemical processes, and d.c. motor drives.

D.C. Voltage Control

The very simplicity of the metal rectifier brings its own limitation in that the d.c. voltage obtainable is not subject to adjustment without the introduction of some other device to change the value of the a.c. input voltage to the rectifier. This same limitation applies also to mercury-arc rectifying devices except that with the latter, voltage reduction by grid or phase control is possible.

Methods of voltage control applicable to all types of rectifier are forms of saturable reactor, on-load tap-changing, variable ratio transformer devices, and induction regulators, all of which add considerably to the first cost.

Phase or grid control of a mercury-arc rectifier is in practice limited either to a small range or for very short periods for such duties as motor starting or to use with equipments not of large power since voltage reduction from the natural voltage is obtained at the expense of power factor and with increase of harmonic currents drawn from the supply.

For variable speed drives a phase-controlled rectifier-d.c. motor combination can equal the range and accuracy of speed achieved by the well-known Ward-Leonard combination of motor-generator set and d.c. motor. Reversing and braking introduce complications and consequently for reversing duty the simplicity of control of the Ward-Leonard system is not matched.

Fig. 5 is a simplified diagram of phase control used for speed regulation of a d.c. motor, the rectifying devices being in this case ignitrons which are essentially single anode valves with a mercury pool cathode. The ignitrons are connected in bridge formation.

Anode to cathode conduction is initiated by the igniter, an electrode which is permanently immersed in the mercury pool; this creates the cathode "spot" (the electron source) when it receives an impulse of current from the control circuit.

As the pulse of igniter current can be made to occur at any time during the period that the valve anode is sufficiently positive to enable it to carry current, phase-controlled rectification is achieved and the d.c. voltage

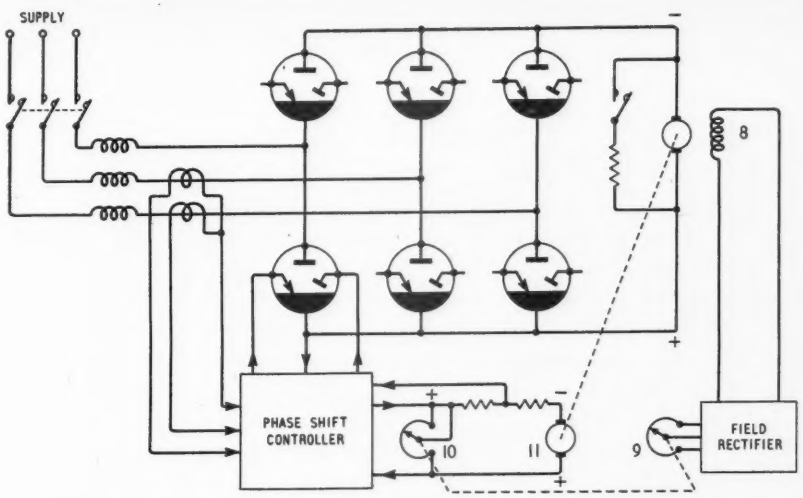


Fig. 5 (above).—Simplified diagram of emotrol circuit for variable speed drive (B.T.H. Co.)
Fig. 6 (right).—Grid controlled single-anode rectifier of excitron type (General Electric Co.)

applied to the motor armature thus varied from zero to its maximum.

In the particular equipment illustrated variable excitation of the shunt field 8 is obtained from an auxiliary metal rectifier; the magnitude of the field voltage is determined by the setting of rheostat 9. This rheostat is mounted on the same operating shaft as rheostat 10 which controls the armature voltage. The control potentials from these two rheostats are co-ordinated so that variable armature voltage control and then variable shunt field control are obtained as the speed of the motor is raised from zero to maximum value. A tachometer-generator 11 driven by the controlled motor provides a feed-back voltage which is compared with an adjustable reference voltage from the speed control rheostat 10 and the resultant difference voltage is fed to an amplifying circuit. The latter circuit controls the firing point of the ignitrons, thus an automatic regulating action is introduced to maintain substantially constant preset speed and the accuracy of this speed control can be better than 0·5 per cent at top speed while good control over a 100/1 speed range can be obtained.

Fig. 6 shows an air-cooled, steel tank pumpless grid controlled single-anode rectifier designed primarily for motor drives. Six of these cylinders in bridge connection are suitable for running four or five 50 h.p. motors in a printing press drive.

Fig. 7 illustrates a grid-controlled steel tank equipment associated with a 300 h.p. drum winder under closed loop speed control. During retardation or with an overhauling load, the rectifier operates as an inverter and returns a.c. power to the supply system. A saving of some 16 per cent in power is achieved as compared with a conventional a.c. winder, and this is the first example in this country of this application of a mercury-arc rectifier.

Stepping up in size is an installation of d.c. motors totalling 28,000 h.p. fed from a 21,000 kW multi-anode pumpless rectifier group. The motors of this installation drive an 80in hot strip mill and the rectifiers form a 60-phase installation, arranged with grid control for starting and for maintaining constant output voltage.

Electro-Chemical Applications

As previously mentioned, metal rectifiers provide a means of producing low d.c. voltages with reasonable efficiency and consequently they have been used extensively

Fig. 7.—Grid control gear, pumpless steel tank rectifier and transformer for 300 h.p. winder motor (Metropolitan-Vickers Electrical Co.)

in the electro-chemical industry for electro-plating, electrolytic cleaning, and as a source of power for electrolytic cells for the production of chlorine, hydrogen, etc.

Where the process or the size of the installation permits the use of higher d.c. voltages the mercury-arc rectifier has been used with advantage for electro-chemical duty since it then scores not only in efficiency but is lower in first cost and space required.

In the medium voltage range one of the most notable installations in this country for heavy electro-chemical duty

is that at the Ellesmere Port Works of the Associated Ethyl Co., Ltd., the circuit of this installation being illustrated in Fig. 8.

The capacity of this plant is 22,400 kW 0/420 V and the type of rectifier is the multi-anode pumpless steel tank. From Fig. 8 it will be seen that the principal method of voltage control is by the use of series regulating transformers fitted with on-load tap-changing equipment. It will also be seen that although the individual rectifier transformers are six-phase the equipment as a whole operates 48 phases, the rectifier transformers having alternative star and delta primaries and the twelve-phase groups so obtained phase displaced by $+11\frac{1}{4}$, $+3\frac{3}{4}$, $-3\frac{3}{4}$ and $-11\frac{1}{4}$ degrees respectively. When large blocks of power are required the need for reducing harmonic currents drawn from the supply to values which are small in relation to the size of the system is becoming more and more recognised.

Fig. 8.—Above: Rectifiers and control cubicles of 22,400 kW steel tank rectifier installation (B.T.H. Co.). Below: A diagram of the main connections

Fig. 9 shows the input current waveform of an installation comprising main, phase shifting and auxiliary transformers for an 18,000 kW 24-phase rectifier installation in Portugal for the production of hydrogen by electrolysing water. This is practically sinusoidal in spite of the presence of about 2·6 per cent fifth and 1 per cent seventh harmonics in the a.c. voltage before adding the rectifier load.

Types of Mercury-Arc Rectifiers

A purchaser when considering the use of mercury-arc rectifiers may have before him the choice of a number of different types, such as single-anode or multi-anode; glass or steel construction; with or without vacuum pumps; air or water cooled.

This choice is not so wide to a purchaser in this country as to one receiving tenders from all parts of the world since the lines of development have differed considerably between American, British and Continental makers.

The considerable expansion in the heavy electro-chemical field in America, particularly for the production of aluminium and magnesium during the last war, was largely carried out with the use of water-cooled pumped ignitrons.

In the ignitron the cathode spot on the mercury pool is ignited by a current pulse to a small high resistance igniter prior to carrying current at each cycle and this allows the anode to be closer to the cathode with a conse-

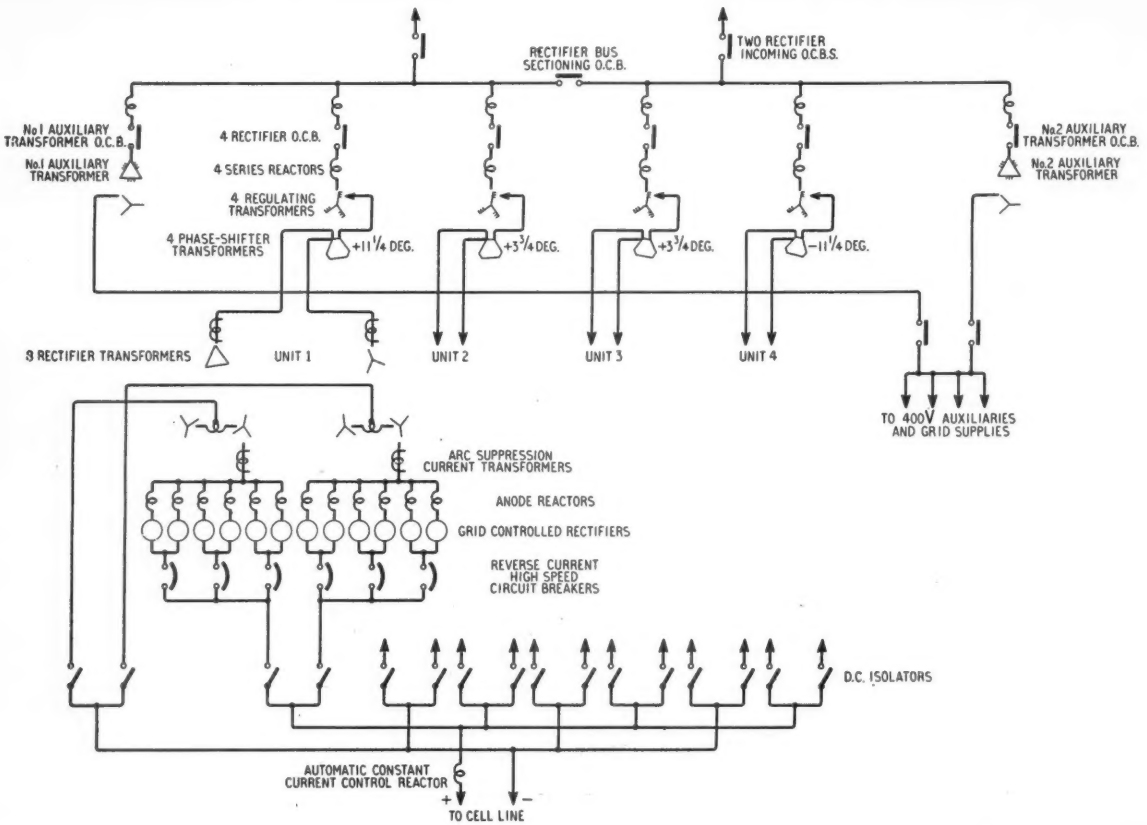


Fig. 9.—Input current waveform of 18,000 kW rectifier installation

quent lower arc drop than was possible in the large 12-, 18- and 24-anode water-cooled tanks—the alternative available at that time for heavy current work.

However, the development of the sealed six-anode tank in this country and the technique of running a group of these in parallel—as compared with six single-anode tanks for six-phase working—provided an alternative solution with very little difference in arc loss, plus the very decided advantages in the elimination of vacuum pumping apparatus and water cooling: consequently, the heavy current ignitron has not found favour in this country.

Another form of single-anode mercury-arc rectifier is the excitron in which a small excitation current flows continuously and this has been developed for both high-voltage and low-voltage working. Fig. 10 shows six high-voltage excitron tubes each rated 59 kW 8 kV mounted in a cabinet assembly for a 30 kW radio transmitter.

It can be said that the technique of pumpless working applied to steel tank rectifiers was widely developed in this country and was only taken up later by American and Continental manufacturers. One can hazard a guess that the incentive to make a steel tank rectifier pumpless was stronger in this country because of the success here of the glass bulb type which also operates without pumps.

There is a limit to the size of glass envelope which is strong enough to withstand evacuation and individual glass bulb rectifiers are not made for ratings of much more than about 400 A. It is generally accepted that the economic size of multi-anode steel construction is above this limit.

The glass bulb rectifier is thus at an obvious advantage for relatively small outputs. However, the technique of operating bulbs in parallel has been successfully developed and the size of large assemblies of glass bulbs has been kept down by the use of segmental shaped bulbs over one fan in a common cubicle, so that equipments of a very large capacity have been successfully constructed.

In large glass bulb installations the relatively small rating of the individual bulbs is claimed as an advantage since the loss of one bulb reduces the available output remaining by only a small percentage. Nevertheless, this relatively small rating makes it essential that each bulb is protected by fuses in its anode circuits whereas the protection of steel tank assemblies can be designed without the need for such fuses. Further, the multiplicity of bulbs makes the provision of grid control of any form much more expensive to provide. In the system shown in Fig. 8 grid control was used with pumpless steel tank rectifiers for the double purpose of arc suppression and for automatic constant current control.

The choice, however, between glass bulb and steel tank is often one of individual preference.

The water-cooled multi-anode rectifier can now be regarded as obsolete and the adoption of pumpless operation is in America rapidly spreading to larger and larger sizes of single-anode rectifiers.

On the Continent the elimination of water cooling on multi-anode rectifiers was adopted while still retaining vacuum pumping apparatus instead of eliminating both as

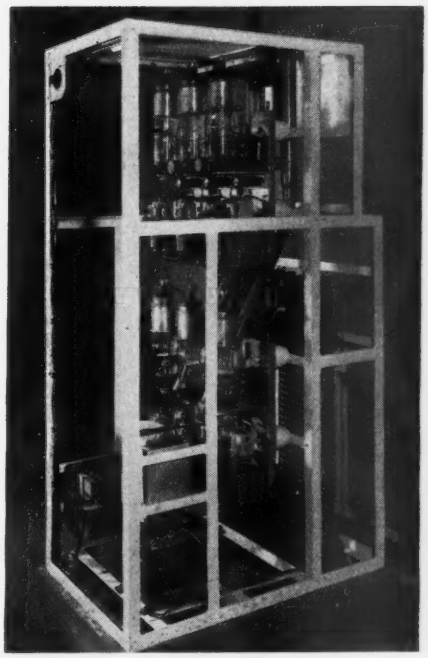


Fig. 10.—Assembly for 30 kW transmitter, incorporating six excitron tubes (English Electric Co.)

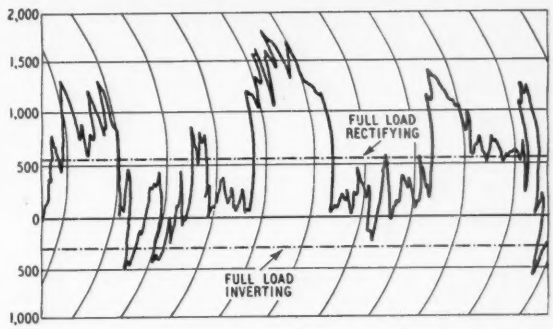


Fig. 11.—Load chart of 3,000 V reversible units

was generally the practice in this country, but here again the adoption of pumpless operation is spreading.

Traction Rectifiers

For traction substations the type of rectifier selected in this country since the war has either been the pumpless air-cooled type or glass bulb type.

The bulk of d.c. railway electrification in this country is at 630 V d.c. with some sections at 1,500 V d.c. the most important of which is the section from Manchester to Sheffield. Most recent new d.c. electrification schemes abroad have been at 3,000 V.

In certain schemes abroad where long and steep gradients are involved it has been considered worth while to cater for regenerative braking by the use of mercury-arc rectifiers (inverters) to return power from locomotives regenerating back to the a.c. supply system. The first British inverters are 3,000 V reversible units on the Natal section of the South African Railways. Twenty 3,000 V reversible units with a rating of 1,667 kW (later raised to 2,000 kW) when used as rectifiers and 1,000 kW when used as inverters were supplied for this system. These are of the water-

cooled pumped type and were supplied in 1935. Fig. 11 shows a load chart taken on this system.

It is, however, a feature of inverted working that the inverter operates at low power factor and that large harmonic currents are drawn from the a.c. system. Such harmonic currents can give rise to extensive telephone interference, especially if telephone lines parallel the track as is usually the case, and make necessary very heavy expense in re-routing telephone lines.

The cost of such equipment involving as it does a separate rectifier to handle the forward and reverse power respectively means that there are very few cases where the amount of power saved will justify the expense and more recent installations rely on loading resistance—sometimes electronically switched across the line when required—as a means of absorbing any surplus power regenerated which is not fed back into other trains on the section.

The use of low frequency alternating current for traction has been long established but not developed to any extent in this country. The attraction of using a.c. is the relatively high voltage which can be employed thereby reducing the size and weight of the contact wire and at the same time permitting the points of supply to the contact wire to be much more widely spaced than is possible with the relatively low voltage possible for d.c. traction.

A satisfactory single-phase 50 c/s a.c. motor for traction is not, however, an easy machine to produce and most a.c. traction systems operate at a low frequency, $16\frac{2}{3}$ or 25 c/s, which makes necessary special alternators or frequency conversion.

By mounting rectifiers on the train itself the advantage of using a.c. transmission at 50 c/s with d.c. traction motors becomes possible and such equipments are in use in France and America while experimental equipment has now been tried in this country. Fig. 12 shows two steel excitrons, complete with fans and ducts for mounting in an undercar box.

Contact and Semi-Conductor Rectifiers

The last few years have seen the development of the contact rectifier primarily for heavy current, medium voltage electro-chemical duty. Except where a very wide range of d.c. voltage control is necessary the contact rectifier supersedes motor generator sets and rotary and motor convertors because of its very high efficiency—of the order of 97 per cent.

In the contact rectifier the change from one phase to another is performed by the opening and closing of contacts at the precise moment every cycle and it is a notable achievement that such complicated equipment operates satisfactorily. The contact rectifier overlaps very little the field covered by the metal plate and mercury-arc rectifiers.

Much more recently the semi-conductor rectifier has been introduced into the power field. Semi-conductor rectifiers capable of dealing with currents in the milliampere range have been in use for some time but the first rectifier of this type to operate in the kilowatt range was installed in the makers' works in December, 1953, to supply d.c. to electrolytic cells for hydrogen production. This unit was rated at 300 kW, 273 V, 1,100 A. In August, 1955, a unit rated at 1,000 kW, 255 V was commissioned for supplying current to an electrolytic cell line and the same manufacturers have announced that they have under construction an 18 MW equipment.

These semi-conductor rectifier installations employ the germanium cell and operate at an efficiency of the order of 97 per cent and therefore are an alternative with equal efficiency to the contact rectifier in its own particular field, and they offer this performance in a much simpler manner. A typical germanium power cell is shown in Fig. 13. The only moving part involved in an assembly of these is a small fan.

A comparison between the voltage loss in metal plate and mercury-arc rectifiers was given at the beginning of this article. It is interesting to see how these figures compare with the loss in germanium cells.

Figures so far officially published give a voltage drop of 0·5 V and a working d.c. voltage of 90 for a single cell, although it is well known that when the cells are graded after manufacture a certain percentage are found to be quite suitable for operating on higher voltages.

With germanium cells in a three-phase bridge connection as many as twenty cells can be connected per arm before the total voltage drop equals 20—and 20 V we can take as an average value for the drop across the arc of a mercury-arc rectifier—and if a working voltage of 75 per cell is used it will be seen that the operating voltage must be above 1,500 before the mercury-arc rectifier matches the germanium rectifier in efficiency. This is, of course, only a very rough comparison but it is a pointer to the possibilities in the future.

That a germanium rectifier assembly is suitable for working at 1,500 V is confirmed by a recent announcement made of a 750 kW 1,500 V germanium rectifier carried on a train and operating on the same experimental section of British Railways on which train mounted mercury-arc rectifiers have also been tried, as referred to above.

The germanium rectifier with a lower voltage drop per cell than occurs across an individual selenium plate can also be a competitor of metal plate rectifiers. Thus it will be seen that the germanium rectifier is already challenging the metal rectifier, the contact rectifier, and the mercury-arc rectifier in the particular field in which each was previously supreme.

It would be a bold purchaser and manufacturer who would now decide to install a germanium rectifier equip-

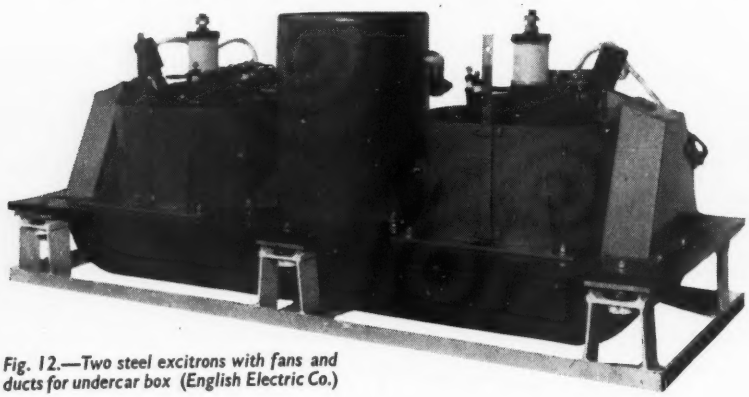


Fig. 12.—Two steel excitrons with fans and ducts for undercar box (English Electric Co.)

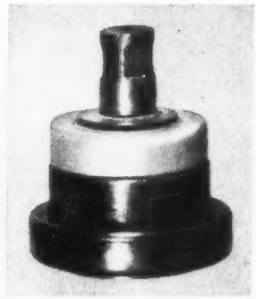


Fig. 13.—50 A germanium rectifier cell. (British Thomson-Houston Co.)

ment for an output of 100,000 A at 1,000 V, a typical rating for a modern aluminium cell line, but it is not outside the bounds of possibility that this will be done within a few years. It is also possible that the introduction of the germanium rectifier equipment which can give an efficiency of the order of 97 per cent at a relatively low voltage may reverse the tendency in the past of increasing the working voltage of cell lines in order to achieve the higher efficiency obtainable from mercury-arc rectifiers as their working voltage is increased. Certainly, operation at high voltages brings with it serious disadvantages from the safety point of view.

Perhaps the safest forecast is that in this country the wisdom of continuing the development of the contact rectifier will be seriously considered.

The development of a germanium transistor has at present reached only low current proportions; development of a power transistor can be expected to follow and this will permit of limited voltage control without the use of additional apparatus and so equal this feature which the mercury-arc rectifier can give.

This, however, is not the end of the story. Considerable development work is being undertaken by many different companies on silicon crystal production. Silicon is more difficult to produce in the refined state required for rectifier work but it has not the same limitations as germanium when operating in high ambient temperatures, hence its attraction. The forward voltage drop of the silicon diode is, however, higher than that of the germanium diode so that it is by no means certain what will be the future as between germanium and silicon; probably each will find its own field of application.

The author wishes to thank all those firms which have supplied illustrations. It should be pointed out that the photographs have been selected solely to illustrate various points mentioned in the text and are by no means representative of the complete range of manufacturers' products.

Since this article was written considerable progress has been reported in the development of germanium and silicon rectifiers.

A number of germanium rectifiers are now in service, including three rated at 1,000 kW at d.c. voltages of 250 and 255, and two rated at 15,000 A at 18 V. The B.T.H. Company also announces that they are to supply for British Railways thirty-five germanium equipments for multiple-unit motor coaches following the successful performance of the 750 kW experimental unit on the Lancaster-Morecambe-Heysham line, referred to earlier in the article.

Letter to the Editor

Letters should bear the writers' names and addresses, not necessarily for publication.
Responsibility cannot be accepted for the opinions expressed by correspondents.

Home-Made Electrical Apparatus

I HAVE been in correspondence for some time with the editor of one of the journals in this category, and it has been with keen interest therefore that I have followed the views of your various readers.

In the current issue of the journal I have in mind it is admitted that the I.E.E. and the Royal Society for the Prevention of Accidents are rightly concerned regarding the safety of amateurs who make their own electrical apparatus and carry out their own electrical repairs, and it goes on to point out that hundreds of thousands of homes are provided only with two-pin socket outlets and earthing therefore is difficult. This fact cannot of course be disputed, but the observation is followed by " There thus can be little risk." The same paragraph states " The ' Do it Yourself ' movement unfortunately is resented by some professional associations in the interests of their own members."

Now I do not think, and I am sure the vast majority of responsible electrical engineers and supervisors agree, that there is any grumble at all with the " Do it Yourself " principle, for there are few who can afford to have it all done for them, and in any case there is often enjoyment in doing it ourselves.

This view has already been expressed in partial defence of the type of journals under discussion, but surely the point at issue is not being told *how* to do it, but being *wrongly* instructed. Could anyone possibly defend a recent article describing how to fit a removable flexible to a standard lamp, which not only described how to fit a socket to the base of the standard but gave also a handsome diagram of a length of twin-twisted flexible with a male two-pin plug at each end? The potential dangers here, particularly where children are concerned, are frightening to think about.

In the same way as the supply authorities are called upon, among other things, to " secure the safety of the public " under the Electricity Supply Regulations, I feel also that the legislature should consider whether it would not be advisable to give some measure of protection to the public through statutory regulations designed to ensure the minimum standard of safety in the publicly-suggested methods of make-up of articles for use on the mains and also in repairs to existing equipment and installations. Such legislation would too, I would hope, be the thin edge of the wedge regarding the quality control of manufactured electrical articles.

Southampton. A. J. PEARSON.

Flameproof Enclosures

RECOMMENDATIONS for the construction of flameproof enclosures of electrical apparatus have been issued as Publication 79 (first edition) by the International Electrotechnical Commission, 1, rue de Varembe, Geneva, at 7·5 Swiss francs plus postage. They consist of 19 clauses concerned with prevention of communication between inflammable gas or vapour under explosion pressure inside an enclosure with inflammable gas or vapour outside it following deformation or damage of the structure or by way of openings such as joints, glands, or venting devices. Tables are included giving maximum permissible structural gap dimensions and ascertained values of explosion pressure, safe gap and ignition temperatures for 36 inflammable gases, together with twelve drawings illustrating some of the basic principles.

GENERATION AND DEVELOPMENT

Lower Output in First Quarter

The latest return issued by the Ministry of Power shows that 2 per cent less electricity was sent out for public supply in the first three months of this year than in the corresponding quarter of 1956. The total amount generated was 24,708 million kWh, a reduction of 496 million. The year began with a moderate increase of 5·1 per cent in January which was followed by a 10·4 per cent decline in February, partly accounted for by the extra day in that month last year, and a further decrease of 0·2 per cent in March. Weather conditions have, of course, been much milder this winter, particularly in February.

ELECTRICITY GENERATED AND SENT OUT FOR PUBLIC SUPPLY

	Fuel consumed Thousand tons			kWh generated Millions			kWh sent out Millions	Installed capacity (m.c.r.) MW
	Coal	Coke and Breeze	Oil	Steam	Water power	Total		
Central Electricity Authority ...	3,682	73	11·2	7,113	16	7,135	6,697	22,604
North of Scotland H.E.B. ...	10	—	1·2	16	158	179	178	807
South of Scotland E.B.	231	4	0·1	440	34	474	448	1,368
Total for March, 1957	3,923	77	12·5	7,569	208	*7,788	7,323	24,779
Corres. total for March, 1956 ...	3,978	91	32·4	7,659	133	7,806	7,339	22,615
Inc. or dec., per cent	−1·4	−15·3	−61·3	−1·2	+56·5	−0·2	−0·2	+9·6
Total to date (3 months) 1957 ...	12,469	255	39·0	23,905	766	24,708	23,258	
Total for corres. 3 months of 1956	13,051	272	104·9	24,686	461	25,204	23,728	
Inc. or dec., per cent	−4·5	−6·3	−62·8	−3·2	+66·2	−2·0	−2·0	

* The total figure includes generation by other methods amounting to 11 million kWh.

In the first quarter of the year 2,733 million kWh was generated by industry (excluding railways, transport undertakings, coal mines, gas works and petroleum refineries) against 2,627 million kWh in the corresponding period of 1956, an increase of 4 per cent. Of this total the chemical industry produced 817 million kWh (+11·5 per cent), the iron and steel industry 600 million kWh (+1·6 per cent), the paper industry 555 million kWh (+5·7 per cent) and the engineering industry 347 million kWh (−6·9 per cent). The figure for the chemical industry includes production by the United Kingdom Atomic Energy Authority at Calder Hall. The total generated there from September, 1956, to March, 1957, was 108 million kWh.

The total plant installed at 31st March was 24,779 MW, an increase during the month of 109 MW. New plant commissioned in C.E.A. stations included generating sets at Acton Lane "B" (Richardsons Westgarth 30 MW), Marchwood (English Electric 60 MW) and Lincoln (Brush 20 MW) and the following boiler plant, in k lb/hr:—Portishead "B," Nottingham H.P. and Acton Lane "B" (Mitchell, 300, 300 and 240, respectively); Carmarthen Bay and Ocker Hill "A" (Babcock & Wilcox, 240 and 180); Marchwood and East Yelland (John Thompson, 550 and 180); Goldington (Clarke Chapman, 300); Chadderton "B" (Simon-Carves, 360); Lincoln (Richardsons Westgarth, 120); and Connah's Quay (International Combustion, 300).

I.O.M. Plant Extension

A new 2,000 kW diesel generator is to be installed in the Peel power station of the Isle of Man Electricity Board. The plant will then comprise a 7,920 kW and two 2,000 kW sets which should be sufficient to meet the growth in load over the next two years.

Power Station Batteries

For the new extension to Nottingham power station, the Tudor Accumulator Co., Ltd., has supplied the Central Electricity Authority with three station batteries and associated charging and control equipment, and d.c. distribution switchboards. The largest of the three is a 240 V battery of 120 L150/17 cells with a capacity of 1,200 Ah at the 10-hour discharge rate. In the event of a break in the mains supply it provides emergency lighting throughout the station and also supplies essential turbine auxiliaries.

The second battery comprises 55 of the latest type of HPB.25 high performance cells with a capacity of 300 Ah, and provides a d.c. supply at 110 V for closing, tripping, control and indication of the station switchgear. The smallest of the three batteries is made up of 26 S40/11 sealed cells, capacity 200 Ah. It provides a 50 V d.c. supply for the remote control and alarm annunciation equipment.

The 240 V Tudor battery at Nottingham power station for supplying emergency lighting and essential turbine auxiliaries in the event of a station auxiliary feeder failure

OVERSEAS

Spanish Power Scheme

A Swedish contracting firm, Widmark & Platzer AB, of Stockholm, has recently signed a contract with Iberduero S.A., of Bilbao, Spain, to act as technical consultants for the subterranean construction work for a power station at Aldeadávila. Situated on the Duero River in north-western Spain, the power station will have a capacity of 700 MW. The tunnelling work will require the removal of some 600,000 cu metres of rock.

N.S.W. Reorganisation Plan

The Electricity Authority of New South Wales has announced a plan to amalgamate electricity distribution undertakings in most of the State into 31 large county councils. The plan, which aims to keep supply costs down by increasing efficiency, has yet to be approved by the Minister for Local Government, Mr. J. B. Renshaw. If it is approved the amalgamation is expected to be completed within twelve months.

The reorganisation will not include the Western Division. Distribution in Eastern and Central N.S.W. will be controlled by 33 bodies, including the 31 large county councils, instead of 98 undertakings as at present. These will take bulk supplies from the Electricity Commission, which generates almost all the State's requirements. Notable exceptions will be the City of the Blue Mountains, which will continue to be responsible for distribution in its area, and Tweed Shire, which will obtain power from

the Southern Electric Authority of Queensland.

The plan aims to complete as quickly as possible the reorganisation which has been proceeding piecemeal for the last ten years. New South Wales is the only State in which distribution has remained substantially in the hands of local authorities.

The chairman of the Authority, Mr. V. J. F. Brain, said on 3rd April that the Local Government Electricity Executive had already considered the plan and had endorsed many of the proposals, although there were some strong differences on detail. "We feel that we have demonstrated that the county council system is successful and we are anxious to complete the job," said Mr. Brain. "We believe that if we do not strengthen local government in this way, electricity distribution could be taken over by a State-wide body. The records of the present county councils show that their costs have remained steady in the face of rising wages and the rising cost of living. We are convinced we will give a better price and a better service with county councils than with individual councils."

British Guiana Proposals

The Georgetown, British Guiana, correspondent of *The Times* reports that the Government is considering the acquisition of the Demerara Electric Co. and the establishment of a public electricity corporation.

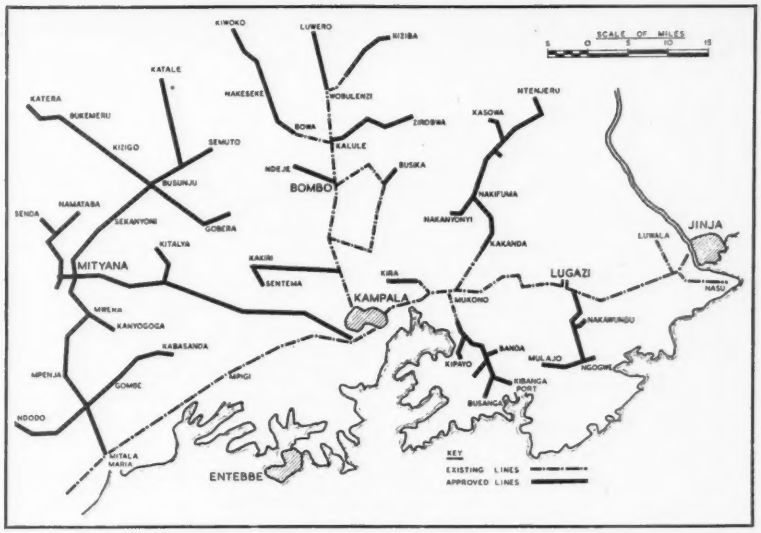
Permission has been given to the Demerara Bauxite Co. to undertake a detailed survey at Great Falls, Mallali, on the Demerara River, to determine whether hydro-electric development there is economically and technically feasible.

Uganda Distribution Schemes

A large part of Mengo and an area between Pallisa and Mount Elgon in the Eastern Province of Uganda are to be supplied with electricity. This announcement last week by the Uganda Electricity Board is indicative of the Board's intention to bring supplies of electricity to the rural districts of the Protectorate on a wide and ever-expanding scale. The news follows the recent decision to establish a small independent scheme for Mbarara and to extend supplies to Mityana.

The new Mengo distribution scheme, which includes many villages, stretches from Matera in the west to Ntenjeru in the east and extends to Kiwoko in the north and as far south as Kibanga Port, Mulajo and Ngogwe. The Pallisa-Mount Elgon scheme covers an area bounded by Pallisa in the west, Kumi in the north, Busulani and Bulucheke in the foothills of Mount Elgon, in the east, and Mainze and Budaka in the south.

Contracts for the erection of the lines to be constructed under the two schemes, and for the lines of the Mityana scheme, will shortly be placed. In all, about 600 miles of line will be erected and work on the main construction will take about three years. The total capital cost of the lines, transformers, switchgear, etc., of all three schemes will be over £1,000,000. The speed of carrying out further similar schemes will depend largely on the advantage taken of the supplies of electricity now being made available.



Map of the Mengo distribution scheme in Uganda

Among the premises which will enjoy the advantages of a public supply of electricity are ginneries, tea estates, coffee factories, missions, hospitals, schools, Government offices, shops and domestic dwellings, and Saza and Gombolola headquarters.

In the first three months of this year 34 million kWh was generated by the Uganda Electricity Board, compared with 22·2 million kWh in the same period last year, an increase of 53 per cent.

Dominican Hydro-Electric and Irrigation Project

The Dominican Republic has completed plans for the construction of the Tavera Dam across the River Yaque del Norte. The 250ft high arch dam will increase electricity supplies and provide water for the irrigation of large areas in the Cibao, the principal agricultural region of the country. The estimated cost is about $15 million (£5,400,000).

The hydro-electric plant will have a capacity of 40 MW and the annual output will amount to 58 million kWh in years when water reserves are low, rising to a maximum of 120 million kWh in normal years.

The dam represents a further stage in the economic progress of the Dominican Republic, which for some years has been promoting with notable success various measures for the development of industry and agriculture. Since 1955, for example, the year in which it was nationalised, the Dominican Electricity Corporation has increased its generating capacity by nearly 30 per cent.

Clearing Transmission Line Route

Survey teams preparing for the Kariba electrical transmission lines have cleared a 4ft wide passage for 500 miles through virgin bush in Northern and Southern Rhodesia. This is only part of the enormous task of building 3,600 transmission towers and erecting nearly 1,000 miles of line to carry Kariba's electrical output over the Federation.

Canadian Water Power Resources

The Water Resources Branch of the Canadian Department of Northern Affairs and National Resources has issued its annual review of water power resources and of their development. The report states that there was pronounced activity in hydro-electric construction throughout the country during 1956 and it is evident that this general trend is continuing vigorously. A total of 845,000 h.p. of new capacity was brought into operation during the year and the construction of additional hydro-electric capacity is being accelerated; about 3,500,000 h.p. is planned to come into operation in the years 1957 and 1958 and an additional 4,500,000 h.p. is planned for later years.

The present recorded water-power resources of Canada are shown as totalling over 57 million h.p. at average flow, representing a feasible turbine installation of about 74 million h.p. The total turbine installation at the end of 1956 is given as 18,356,148 h.p., indicating that less than 25 per cent of available resources has been developed. Of hydraulic plants, 87 per cent serve as central electric stations and, in 1956, production reached a new high level. The pulp-

and-paper and the mineral industries are the most important consumers.

British Columbia, which is the third largest of Canadian provinces in population and in total hydro-electric installation, moved to first place in *per capita* installation during 1956 with a rate of 1,859 h.p. per 1,000 population. Although its population is much lower than that of Ontario or Quebec, large blocks of power are required for its metallurgical, mining and forest products industries. The province of Quebec ranks second with 1,832 h.p.; its immense production of aluminium and newsprint absorbs large quantities of power and appreciable amounts also are transmitted to Ontario.

Electricity Supply in Europe

The fourth "Quarterly Bulletin of Electric Energy Statistics for Europe" (unavoidably delayed) has now been published by the United Nations (1s from Geneva or local agents). It tabulates information in respect of 25 countries, including the U.K., U.S.A. and U.S.S.R., relating to net production, international exchanges and gross consumption, month by month, from 1st October, 1955, to 31st December, 1956, where the figures are available. In some cases returns for the last few months have not been received.

The data includes generation (after deducting consumption of auxiliaries) in public supply and industrial power stations (divided into thermal and hydro-electric stations) and imports and exports measured near the frontiers of the countries concerned. A column has been ruled for nuclear reactor plants, but at present contains no figures.

Cost of Snowy Mountains Scheme

In its annual report the Snowy Mountains Hydro-Electric Authority says that the cost of power from the project has been substantially increased as a result of the continued rise in interest rates on advances for construction works made by the Australian Government. Another factor has been the obligation to supply, free of charge, nearly two million acre-feet of irrigation water annually to the Murrumbidgee and Murray River systems.

Power for Nickel Development

The Manitoba Hydro-Electric Board is to harness the Nelson River at Grand Rapid to provide power for a $175 million nickel development by the International Nickel Co. of Canada, Ltd., in the vicinity of Mystery and Moak Lakes. The station will be the largest in the province, with an initial capacity in 1961 of 200,000 h.p. and an ultimate capacity of 400,000 h.p.

Modification of Canadian Reactor

The three parties responsible for the 20 MW reactor at Des Joachims, Ontario, Atomic Energy of Canada, Ltd., the Hydro-Electric Power Commission of Ontario and the Canadian General Electric Co., Ltd., have announced that the construction of the reactor has been temporarily suspended to enable later technological advances to be incorporated. It is not intended to depart from the basic principles of the design—heavy water moderator and natural uranium fuel.

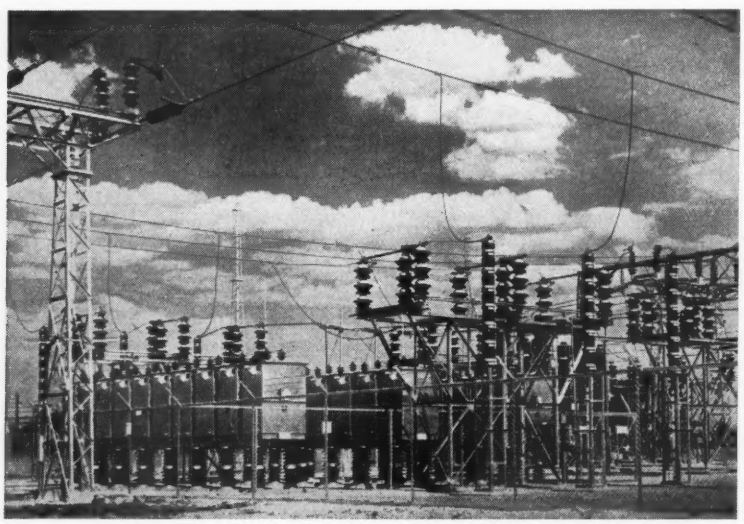
Yellow River Scheme

Work was begun on 13th April on the Sanmen dam, the first of a series of forty-six to be erected on the Yellow River in China. Reporting this, *The Times* states that the dam is to be about 500ft high and 2,600ft across, and in addition to providing water for irrigation will have power plant rated at over a million kW.

Large Series Capacitor Installation

At Hartley, Southern Rhodesia, a large series capacitor installation in the Umniati-Norton 88 kV transmission line is successfully nearing the end of its first lightning season. These capacitors were supplied to the Electricity Supply Commission of Southern Rhodesia by British Insulated Callender's Cables, Ltd., and were commissioned on 14th August, 1956.

Although the theory of the use of power capacitors in series with distribution or transmission lines has been understood for many years, it is only recently that practical applications have tended to come into use. Previously, power capacitors had been used almost exclusively in parallel with inductive loads to improve the overall load power factor. Series capacitors, however, are connected in the power line itself, usually near its mid-point. In this position, they regulate the line voltage and increase the stability and the power transfer of the line.



View of the capacitor installation in the Southern Rhodesian 88 kV transmission line

The Hartley installation is in three sections, one in series with each line conductor. When the line is transmitting normal full load current, the total output of the sections is 6,000 kVAr. Under these conditions the voltage across each section is 10 kV. The power handling capacity of the Umniati-Norton transmission line is raised, within the limits of acceptable voltage drop, by 100 per cent when the capacitors are in circuit. The installation was erected by the Electricity Supply Commission, while B.I.C.C., who manufactured and supplied the capacitors, copper connections and the supporting insulators and steelwork, assisted the Commission in the planning and engineering of the scheme.

Protective equipment for the capacitors was supplied by A. Reyrolle & Co., Ltd. This consists of arc gaps which are set to flash-over and energise relays when the voltage across the capacitors reaches twice the normal capacitor voltage of 10 kV. The relays then cause a circuit-breaker to close and short out the capacitors and spark gaps for a controlled period. Line protection of the impedance-distance type with carrier acceleration is envisaged, and the capacitor protection was designed so that it will not distort the performance of the distance measuring relays.

Financial Section

STOCKS and SHARES

WITH the Budget and the Easter holiday behind them, Stock Exchange markets have reached a stage at which it is interesting to take stock of the position existing after the mixed fortunes which they have experienced since the beginning of the year. Concerning the industrial market, the most noteworthy feature in the situation at mid-April was the establishment of the share-price index at the highest point for more than a year. Although still well below the top of the boom in 1955, the average stood above the levels ruling before the crises of last summer and autumn. This performance was achieved despite the check at the time of the shipyard and engineering strikes, which made a severe dent in the upward curve during March. A sharp ascent was accomplished in the weeks preceding the Budget, after which the trend remained firm. Comparatively speaking, the gilt-edged market stayed out of favour. It started the year well with the reduction in Bank Rate, but seemed to become discouraged about the prospects of a further step down in the rate within the early future.

Electrical Shares

Most of the popular electrical equipment and engineering shares have enjoyed the general experience of making plenty of ground, on balance, since the beginning of the year. They felt the impact of the labour disputes, but had the benefit of the impressive expenditure figures revealed in the unfolding of the nuclear power development plans. Company dividends and results on account of 1956 have so far had a mixed influence on prices. Against the reports of lower profits from, for instance, Associated Electrical Industries, Brush, A. Reyrolle and British Insulated Callender's Cables, there have been announcements of expanded earnings from such companies as English Electric, C. A. Parsons, Automatic Telephone, Ericsson and Clarke Chapman.

Upward Trend

In the following table there are indications of the extent to which prices improved, between the turn of the year and Easter, in the case of a variety of well-known electrical ordinary shares:—

Ordinary Share	Price		Gain
	Jan.	April	
A.E.I.	66/3	68/–	1/9
Automatic Telephone ...	52/6	67/3	4/9
Babcock & Wilcox ...	73/9	80/6	6/9
B.I.C.C.	50/3	53/–	2/9
Brush	4/6	6/6	2/–
Chloride Electrical ...	57/6	67/3	9/9
Clarke Chapman ...	127/6	162/6	35/–
Cole, E. K.	16/6	19/9	3/3
Crompton Parkinson ...	13/9	16/9	3/–
E.M.I.	24/–	32/6	8/6
English Electric	48/9	57/9	9/–
Ericsson	34/6	44/9	10/3
Ever Ready	28/3	31/6	3/3
G.E.C.	50/–	57/3	7/3
Henley's, W. T.	15/3	16/–	9d
Hoover	24/6	36/9	12/3
International Combustion	20/–	27/9	7/9
London Electric Wire ...	42/6	53/6	11/–
Lucas	30/9	36/3	5/6
Parsons, C. A.	52/6	70/3	17/9
Plessey	61/–	77/6	16/6
Pye "A"	16/3	18/3	2/–
Reyrolle	91/3	104/–	12/9
S. Smith	12/9	14/9	2/–
T.C. & M.	24/6	29/3	4/9
Thorn Electrical	16/–	22/9	6/9
Vactric	13/–	18/6	5/6
Ward & Goldstone ...	37/6	46/3	8/9

Present Yields

Although there have been a number of moderate increases in dividends this year, the yields obtainable from money invested in industrial ordinary shares has of course been cut appreciably, on the average, by the rise in prices. In the electrical equipment market, many of the leading issues now offer the buyer returns very much in line with the yield of about 4¾ per cent available from War Loan at its present price. Among those which, on the basis of recent prices, pay a little more or less than that rate are the shares of the big groups such as A.E.I., English Electric, G.E.C. and Crompton Parkinson. Others on roughly the same mark include B.I.C.C., E.M.I., E. K. Cole, S. Smith and British Thermostat. Investment is prepared to accept a lower immediate return in cases where the latter is deemed to be of less importance than future prospects: instances are the shares of Parsons, Reyrolle, Plessey, Pye, Thorn Electrical, Elliott Brothers, Associated Automation, Babcocks, and Clarke Chapman. In these cases a buyer at present prices sees a return of well under 4 per cent on the basis of the dividends last paid.

Five per cent Upwards

In the electrical lists there is a variety of shares which show the buyer a return of 5 to 5½ per cent on his investment, at present rates of dividend. They include, among others, the shares of Automatic Telephone (following the recent increase in the distribution), Lancashire Dynamo, Allen West, Desoutter Brothers, Aron Meter, Chloride Electrical and Ever Ready. About or above the 6 per cent yield mark are the shares of Electric Construction, Hoover, Decca "A," T.C. & M., and Duport. In the 7 to 8 per cent bracket are several cable shares, including those of Henley's and Aberdare Cables, also Hackbridge & Hewittic and Crabtree Electrical. Among those showing 8 per cent or more are Aerialite and Switchgear & Cowans.

Westinghouse Issue

Westinghouse Brake & Signal are making the first of the big capital issues to appear since the Budget. Shareholders are offered, for every £1 stock held, one new £1 ordinary share by way of a scrip issue; and for every £3 stock, two new ordinary shares for cash at a price of 35s. From the latter operation the company will obtain rather more than £3 million fresh capital, to be used partly in reducing bank indebtedness and partly in expanding the productive capacity of the group. Results in the first part of the current year are said to have compared favourably with the corresponding figures a year earlier, and in the normal course of events the company anticipates a dividend of 9 per cent on the enlarged capital of £7·1 million, in comparison with last year's 18 per cent payment on £2·7 million capital. At the opening of dealings, the old shares were called 40s 9d ex rights to both issues, with the new "cash" shares at a premium of about 6s on the offered price. At this level the prospective yield is a little under 4½ per cent.

Company News

Market expectations were well satisfied with the Chloride Electrical Storage company's figures for 1956, which are shown in the preliminary statement to be close up to the previous results. Net profits are again a little over the million mark, and cover nearly two and a half times the ordinary dividend, which is brought up to a total of 17½ per cent for the third time running. The price of the £1 shares hardened to 67s 3d immediately after the announcement, making the yield about 5¼ per cent. London Electric Wire £1 shares were not greatly altered, at 53s 6d, after the final dividend declaration, which also makes the same total (in this case 12½ per cent) for the third successive year. Profits are reported to be lower than those of 1955, but a reduced tax charge leaves the net figure slightly higher at £633,000, before writing £100,000 off an investment. Earnings cover the distribution three times over, and the yield on the shares is a fraction under 4¾ per cent.

P.f. Condensers for New Zealand

The *Board of Trade Journal* of 20th April reports that the New Zealand Government has reduced the rates of duty on power factor condensers. British-made condensers of over 15 kVAr will be admitted free of duty. This equipment has also been exempted from surtax and primage.

On account of the Easter holiday we are unable to publish our share list. It will appear as usual next week.

REPORTS and DIVIDENDS

Brush Group, Ltd.—The Hawker Siddeley Group has made an offer to acquire the whole of the issued capital of the Brush Group, Ltd. The details of the offer are as follows:—

One cumulative preference £1 share of the Hawker Siddeley Group in exchange for one Brush 5½ per cent cumulative preference stock unit of £1 (the present rate of dividend on the Hawker Siddeley cumulative preference shares is 5 per cent, but steps are being taken to increase the rate to 5½ per cent, and the offer is made on that basis); four new Hawker Siddeley ordinary shares of £1 each in exchange for five Brush 6 per cent cumulative convertible redeemable preference stock units of £1; and one new Hawker Siddeley ordinary share of £1 in exchange for five Brush ordinary stock units of 5s. The new Hawker Siddeley ordinary shares offered in exchange for the Brush securities will rank for full dividend, interim and final, in respect of the year to 31st July, 1957. The offer is conditional on acceptance by the holders of 90 per cent in value of the total issued capital of Brush, or such smaller percentages as the Hawker Siddeley Group may decide. The directors of the Brush Group will recommend their stockholders to accept these offers and state that they are proposing to accept them in respect of their own holdings.

The Brush Group also announces that, subject to the necessary formalities, it has completed arrangements for the acquisition from Allmanna Svenska Elektriska Aktiebolaget (ASEA), Sweden, of the entire share capital of Asea Electric, Ltd., of Walthamstow. This company is being acquired either for cash or shares at the Brush Group's option, depending on the result of the Hawker offer.

Thomas Bolton & Sons, Ltd.—The annual meeting was held on 17th April, Mr. F. Waine (chairman) presiding. In the course of his circulated statement, Mr. Waine said that the year under review had been one in which considerable fluctuation in copper prices had taken place. The general trend had been in a downward direction, thus reducing the cost of financing their principal raw material. Whilst high prices for copper no doubt contributed to the record turnover achieved, the tonnage output exceeded that of 1955. Present indications were that copper production had caught up with normal demand. In almost all sections of the company's activities production was satisfactorily maintained. The value of direct exports was 50 per cent higher than the figure for the previous year and now represented some 18 per cent of the total sales. In contrast, there was a fall in the volume of orders placed by home customers which was traceable to two causes. Firstly, the recession in trade in some consuming industries due to credit restriction on hire purchase and in bankers' advances, and secondly, the natural tendency of customers to carry minimum stocks during a time of steadily falling copper prices.

Enfield Cables, Ltd.—The annual meeting will be held on 14th May. In his circulated statement Mr. H. J. Randall (chairman) says that the reduction in the profit for the year under review is largely accounted for by losses of £85,000 on stocks, due mainly to the fall in the price of copper, and an increase in interest payable, less dividends receivable, of £33,500. The price of copper fell by no less than £167 per ton from £437 in March, 1956, to £270 in December. It is very unlikely that a loss of such magnitude will occur in 1957.

The outstanding feature of the year was the contraction in demand for cables in this country which was attributable mainly to Government restrictions on credit facilities to industry. In the electricity supply industry capital expenditure was curtailed and cable-making companies were among the first to be affected by the national policy of credit restrictions. Mr. Randall refers to the C.E.A. programme for new power stations and says that if the lack of balance in the development of the electricity supply industry were to be prolonged indefinitely the nation would have an abundance of electricity available at the power stations without adequate means of conveying the supply to the places where it is needed. For a long period of years, therefore, the cable-making industry will be called upon to meet the expanding requirements of electricity which will be increasingly linked with nuclear power. The Government has just announced that the expenditure on the transmission and distribution of electricity is to be increased during the current year, and this should lead to greater activity in the cable-making industry.

In the export markets we are faced with keen competition, and are feeling the effects of inflation on the costs of production. Unless wage increases can be matched by corresponding increases in productivity we shall, in many industries, lose much of the overseas business.

Bylock Electric, Ltd.—The annual meeting was held recently, Mr. C. A. Mathes (chairman) presiding. In his circulated statement, the chairman said that in spite of increased costs and the credit squeeze the output had improved and sales had kept pace in all markets. Addressing the meeting, Mr. Mathes said that the directors were contemplating an application to the Capital Issues Committee with a view to a further issue of bonus shares to bring the issued capital more into line with the actual capital in use. Since 31st July last turnover had shown a substantial increase compared with the previous year and the turnover was well spread between export and home trade.

W. T. Henley's Telegraph Works Co., Ltd.—The preliminary statement for 1956 shows a group trading profit, including £250,000 transferred from prices reserve, of £1,470,642, as compared with £1,897,656 for 1955. After deducting depreciation £385,382, taxation £471,569, interest £49,451, and adding other income, including a profit of £192,570 on realisation of investments, there is a net profit of £930,615 (against £791,172). Transfers to general reserve and other provisions require £550,000, and it is proposed to pay a final dividend of 9 per cent, maintaining the dividend for the year at 11½ per cent. The balance carried forward is £903,026 (against £849,945 brought in).

The Chloride Electrical Storage Co., Ltd., reports that after deducting £1,161,064 for United Kingdom taxation and £154,334 for other taxation, the surplus for 1956 is £1,032,406, as compared with £1,102,083 for the preceding year. To this is added £116,883, profits of previous years, £510,638 brought in, less transfer to specific reserves £434,328, and after deducting £395,335 profits retained by subsidiaries, the balance available is £830,264 (against £913,383). A further interim dividend of 12½ per cent is paid, in lieu of a final dividend, making 17½ per cent for the year (unchanged).

The London Electric Wire Co. & Smiths, Ltd.—The group profits for 1956 amount to £1,015,441, a decrease of £388,626 as compared with 1955, and after providing a sum of £382,559 (£778,908) for taxation, and £100,000 for diminution in value of shares in an associated company, the net profit is £531,257 (against £608,569). It is proposed to pay a final ordinary dividend of 8¾ per cent, maintaining the distribution for the year at 12½ per cent.

Newman Industries, Ltd. — The accounts for 1956, subject to audit, show a trading profit of £202,675, as compared with £219,793 for 1955. After providing for depreciation and £65,000 for taxation, the net balance is £41,219 (against £51,972). The ordinary dividend for the year is maintained at 10 per cent, and the preferred ordinary receive a participating 2 per cent, again making 8 per cent for the year. The balance carried forward is £168,805 (against £146,308 brought in).

Mavor & Coulson, Ltd.—The trading profit for 1956 is £628,690 (against £408,781 for 1955), and after deducting taxation of £323,487, there is a net profit of £305,203 (against £201,061).

General reserve receives £140,000 and it is proposed to pay a final ordinary dividend of 10 per cent (against 7½ per cent), making 17½ per cent for the year (12½ per cent). The balance carried forward in the accounts of the parent company is £137,678 (against £111,669 brought in).

Ozonair Engineering, Ltd.—The trading profit for 1956 is £58,098 (against £25,965 for 1955), and the net profit, after deducting taxation, etc., is £17,813 (£6,101). The proposed dividend for the year is 15 per cent (against 8½ per cent and a bonus of 2½ per cent), and the balance carried forward is £5,713 (against £4,999 brought in). It is proposed to make a one-for-four rights issue of 100,000 new 2s shares at par. Mr. A. G. T. Oakley (chairman) states that the purchase of the freehold of a leased factory for £31,000 has been arranged and will be financed by a mortgage advance of £16,000, an issue of capital, and from existing resources. Further capital may be required at a comparatively early date.

The British Engine Boiler & Electrical Insurance Co., Ltd.—The profit for 1956 is £144,761 (against £248,174 for 1955). Taxation requires £30,000. It is proposed to pay a final dividend of 35 per cent (against 30 per cent), making 65 per cent for the year (60 per cent). The balance carried forward is £405,225 (against £381,163 brought in).

Allen West & Co., Ltd.—The group net profit for the year to 31st January last is £500,062, as compared with £455,400 for the preceding year. Taxation absorbed £482,789. The dividend for the year is unchanged at 15 per cent. It is proposed to make a three-for-ten scrip issue.

Bowthorpe Holdings, Ltd., report group profits for 1956 of £578,221, as compared with £539,949 for the previous year, and a net balance of £284,115 (against £283,865). It is proposed to pay a final dividend of 25 per cent, making 37½ per cent for the year (against 35 per cent). It is also proposed, subject to the consent of the Capital Issues Committee, to make a one-for-one free scrip issue.

The National Electric Construction Co., Ltd.—The group net profit for 1956 is £97,255, as compared with £101,416 for the previous year. Taxation absorbed £82,506. The dividend for the year is unchanged at 17½ per cent.

W. Canning & Co., Ltd.—A net profit of £263,629 is reported for 1956, as compared with £276,931 for 1955. The dividend for the year is unchanged at 25 per cent, with a final payment of 20 per cent.

The Calcutta Electric Supply Corporation, Ltd., has notified stockholders that, in order to conform with the Indian Government's ruling that future accounts must be made up to 31st March in each year, its next accounts will be made up to 31st March, 1957, instead of 31st December, 1956. It is proposed to pay a second interim dividend on the ordinary stock in June next and to recommend a final dividend at the annual general meeting in September next. In subsequent years interim dividends will normally be paid in February. Preference stockholders will receive a dividend on 15th May for the three months ended 31st March last.

Crossley Brothers, Ltd., have declared an interim dividend of 3 per cent (unchanged).

The Electrical Apparatus Co., Ltd., has declared an interim dividend of 7½ per cent (unchanged).

New Companies

Orchard's of Bexhill, Ltd.—Registered 3rd April. Capital £1,000. To acquire the business of electrical engineers and contractors carried on by Herbert Watkinson as "Orchard's of Bexhill," etc. Directors: Audrey Bedson, J. H. Bedson, H. Watkinson and Mrs. Lily E. Watkinson. Regd. office: 1, Sackville Road, Bexhill-on-Sea, Sussex.

County Electrical and Mechanical Wholesalers (Lancashire), Ltd.—Registered 3rd April. Capital £5,000. Directors: A. Trickett (permanent) and Mrs. Maud Trickett. Regd. office: 1a, Smith Street, Atherton, near Manchester.

F. E. Morris, Ltd.—Registered 2nd April. Capital £1,000. To acquire the business of an electrical engineer contractor carried on by F. E. Morris at Slough. Directors: F. E. Morris and Mrs. Olive J. Morris. Regd. office: "Sparkoma," Mina Avenue, Langley Road, Slough.

Eric Ellis (Electrical), Ltd.—Registered 1st April. Capital £100. Electrical contractors, electricians, radio and television dealers, etc. E. H. Ellis signs as director. Regd. office: 30e, Park Road, Bingley, Yorks.

Norman Gentry, Ltd.—Registered 1st April. Capital £5,000. Manufacturers of and dealers in radio, electrical and mechanical apparatus of all kinds, etc. Directors: N. Gentry and E. J. Clay. Regd. office: 95, Prince Avenue, Prittlewell, Southend-on-Sea.

Walkers of Crayford, Ltd.—Registered 4th April. Capital £8,000. To acquire the business of A. F. F. Walker, electrical engineer, carried on by him at Crayford, etc. A. F. F. Walker is the first director. Regd. office: 10, The Parade, Crayford.

B.G. Electrics, Ltd.—Registered 5th April. Capital £2,000. Electrical engineers and contractors, etc. Directors: S. Rose-Neil and N. Augustine. Regd. office: Swinton House, 324, Gray's Inn Road, W.C.1.

Electronic Devices (Cheltenham), Ltd.—Registered 5th April. Capital £2,000. Electronic, electrical and mechanical engineers, manufacturers of and dealers in electronic, electrical and mechanical devices, etc. Directors: S. Kelly and H. Brislin. Regd. office: 27, Rodney Road, Cheltenham.

E. Bennett Williams, Ltd.—Registered 1st April. Capital £6,000. Manufacturers of and dealers in radio and television sets, accessories and apparatus, etc. E. B. Williams is permanent managing director. Regd. office: 7, Palace Street, Caernarvon.

C. A. J. Billington, Ltd.—Registered 4th April. Capital £2,000. To acquire the business of an electrical engineer and contractor and retail radio and television dealer carried on by C. A. J. Billington at Cranfield. Directors: C. A. J. Billington and Mrs. Blanche L. M. Billington. Regd. office: 174a, High Street, Cranfield, Beds.

Robert Gordon (Leicester), Ltd.—Registered 29th March. Capital £1,000. To acquire the business of a wholesaler and importer carried on by R. Gordon at Victoria Passage, London Road, Leicester; and to carry on the business of electrical equipment specialists, etc. Directors: R. Gordon and Mrs. Constance M. Gordon. Regd. office: 12, The Crescent, King Street, Leicester.

William Wroe & Son, Ltd.—Registered 29th March. Capital £2,000. Electrical engineers and general electrical installation contractors, radio and television engineers, etc. Directors: W. Wroe, senr., and W. Wroe, jnr. Regd. office: 112, Oldham Road, Ashton-under-Lyne.

F. H. Alston & Sons, Ltd.—Registered 29th March. Capital £5,000. Electricians, mechanical engineers, manufacturers of and dealers in electrical apparatus, etc. Regd. office: 1141, Coventry Road, Birmingham, 25.

Leslie's Television Service, Ltd.—Registered 29th March. Capital £2,000. Radio, television and electrical engineers, contractors, etc. Directors: L. Gabbitas, Doris H. Gabbitas and P. S. Morgan. Regd. office: 25, Markhouse Road, Walthamstow, E.17.

M. & D. Auto Electrical Supply, Ltd.—Registered 29th March. Capital £500. Regd. office: 44, Islington Park Street, N.1.

N. W. Dixon, Ltd.—Registered 11th March. Capital £6,000. Electricians, electrical contractors and engineers. Directors: N. W. Dixon and Mrs. Annie L. Dixon. Regd. office: The Firs, Rother Street, Stratford-on-Avon.

Morgan Enterprises, Ltd.—Registered 18th February. Capital £5,000. Manufacturers of and dealers in radio and television equipment of all kinds, etc. Directors: A. Morgan, M. L. Morgan, E. H. Morgan and N. G. Morgan. Regd. office: 90, High Street, Barry.

Ashton (E. R. T.), Ltd.—Registered 22nd February. Capital £2,500. Electrical and general engineers and manufacturers of and dealers in radio and television sets, etc. Directors: R. Ashton, Mrs. Ethel Ashton and T. Ashton. Regd. office: 7 & 9, Briggate, Silsden, Yorks.

R. T. Checksfield, Ltd.—Registered 26th March. Capital £1,000. To acquire the business of electrical engineers and contractors heretofore carried on by R. T. Checksfield at The Willows, Westfield Lane, Upper Poppleton, Yorks. Directors: R. T. Checksfield and R. P. Checksfield. Regd. office: The Willows, Westfield Lane, Upper Poppleton, Yorks.

Versatile Electronics, Ltd.—Registered 27th March. Capital £1,000. Manufacturers, repairers, servicers and hirers out of and wholesale and retail dealers in radio, electrical and mechanical apparatus of all kinds, etc. Directors: R. Van-Haaren and S. Burns. Regd. office: 44, Broadway Market, Hackney, E.8.

Macness, Ltd.—Registered 22nd March. Capital £100. Retail dealers, wholesalers, manufacturers of radio, electrical and mechanical apparatus of all kinds, etc. Directors: R. M. M. McLaren and W. F. Baines. Regd. office: 77-79, King Street, W.6.

Butterfield Neon Sites, Ltd.—Registered 15th March. Capital £100. Manufacturers of and dealers in neon letters, neon and other electrical signs, etc. Directors: H. Butterfield and A. Butterfield. Regd. office: 161-165, Westgate, Bradford.

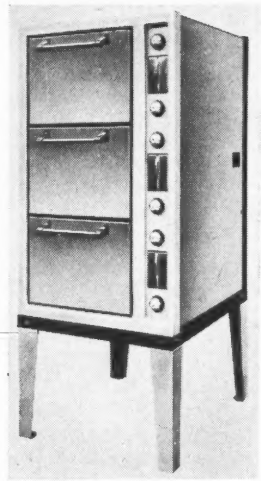
Vectronic Developments, Ltd.—Registered 14th February. Capital £100. Heating, ventilating, mechanical and electrical engineers, etc. Directors: J. H. Cavalier, K. F. J. Inman and W. F. Ralph. Secretary: J. H. Cavalier. Regd. office: 10-13, Dominion Street, London, E.C.2.

Tony Jones (Rumney), Ltd.—Registered 1st March. Capital £500. Electrical contractors, etc. Directors: G. F. A. Jones and G. R. Jones. Regd. office: 13, Weston Road, Llanrumney, Cardiff.

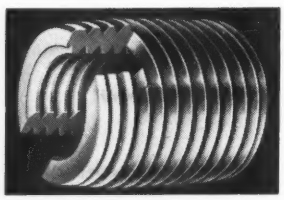
Liquidation

Attracta Electrical & Engineering Co., Ltd.—First and final dividend of 7 3/16d in the £, payable at the office of the Official Receiver and Liquidator, Inveresk House, 346, Strand, London, W.C.2.

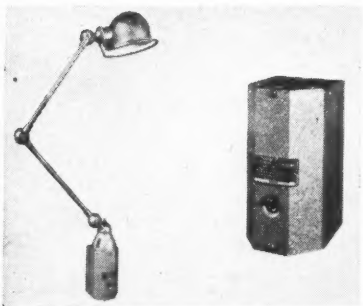
NEW ELECTRICAL EQUIPMENT



G.E.C. three-deck pastry oven



Self-tapping screwed insert (Tappex)



"Infini-Angle" low voltage transformer lighting unit

Wolf general duty, two-speed drill

Electric Space Heater-Cooler

A new electric space heater—or alternatively cooler—which incorporates fan air diffusers and a pre-set time control operating device is announced by GILLOTT ELECTRO APPLIANCES, LTD., Chalford, nr. Stroud, Glos., and has been named "Newday." It is produced in two forms with identical internal equipment but with considerably differing facades. The one is a free-standing unit and the other an inset unit which would normally be a permanent fitting. This second type has a maximum depth of 7in. A special false surround is available for fitting to walls of less depth than this, e.g. partition walls.

As a heater, the "Newday" has 3 kW output which produces a rapid rise in room temperature as the heat is dispersed by the electric fan diffusers. Normally, the fans would operate for the initial period of heat-up and then the unit could be switched to half-heat convection at 1,500 W to maintain temperature.

A time pre-setting device known as the Gillott chronomatic control is incorporated and it has two dials, rotatable for adjustment so that a time control over a maximum of 18 hours is given. One dial gives a pre-set introduction of heating for any period up to 14 hours and the second dial a four-hour maximum band for the heating to be cut off.

The free-standing model has two vertical side panels to the front elevation which light up with a soft illumination when the heater is switched on; this is subdued enough for television to be watched without visual interference.

The cost of the free-standing model is £20 10s plus £8 19s 11d purchase tax in the United Kingdom. The inset model is cheaper but will vary in price according to the method of installation. The dimensions are: max. height 22⅞in; max. breadth 18¼in; max. depth 6⅛in.

Low Voltage Lighting Unit

The BRITISH CENTRAL ELECTRICAL CO., LTD., announces that it is now able to supply its "Infini-Angle" lighting unit fitted with a low voltage transformer. Models are available for 230 V or 400 V primary and 25 V or 50 V secondary, the secondary winding being centre tapped to earth.

The lighting unit has slip-ring joints in all planes and can be positioned anywhere within a sphere whose radius is determined by the number of arms used. It is particularly suitable for use on fitters' benches, presses, lathes and drawing boards, etc., and can be expanded by adding extra arms. The lighting unit is unswitched but an extra switch can be provided if required.

Thread Insert

A range of screwed inserts are now being produced for use with non-ferrous metals and plastics. Where the material is machineable but not of sufficient strength to sustain applied loads, these self-tapping inserts can be successfully used as a permanent fastening. Made in cadmium plated steel and brass for use in wood and plastics, they are internally threaded to receive B.A., B.S.F., Whitworth, metric and U.N. threaded fasteners of all kinds. The manufacturers are TAPPEX THREAD INSERTS, LTD., 46, High Street, Warwick.

Two-Speed Electric Drill

A general duty, ¼in capacity, two-speed portable electric drill is now being made by WOLF ELECTRIC TOOLS, LTD., Pioneer Works, Hanger Lane, London, W.5. This machine will enable users to perform ¼in (high speed) and ½in (low speed) drilling operations in metal at the correct cutting speeds and with the minimum of effort. For hard wood the drilling capacities are higher, i.e. 1in diameter at low speed and ⅜in diameter at high speed.

In order to conform to international requirements the switch handle is fitted with specially moulded insulation. The gearbox assembly incorporates a selector mechanism and the transmission is such that the gears are in constant mesh, speed selection being obtained by the engagement of clutches integral with the final spindle gear wheels. The drill can be supplied for various voltage ranges including 32 and 50 V. A full range of wood drilling bits up to the maximum capacity of the machines is also available together with a range of hole cutters.

Pastry Ovens

Modern styled pastry ovens in two- or three-deck units have recently been developed by the GENERAL ELECTRIC CO., LTD., Magnet House, Kingsway, London, W.C.2. The drop-down aluminium doors, light and easy to operate, are fitted with runners for the baking trays, and secured by bar-

operated latches. Each oven can accommodate a standard 30in by 18in baking sheet and measures 19⅝in wide by 31¼in deep by 9in high. Maximum loading of each deck is 4·5 kW. Two-oven units can be connected to either a single- or two-phase 3-wire supply and the three-deck model to a single- or three-phase 4-wire supply. Oven temperature is controlled by a capillary thermostat with a range of 200/500 deg F. The finish of the one-piece front, legs and body is in mottled grey vitreous enamel and the baking chambers, constructed of mild steel, are finished in mottled black vitreous enamel.

Flameproof Fluorescent Fitting

A flameproof fluorescent fitting which has been designed for safe operation in atmospheres where inflammable vapours and explosive gases may be present, is being manufactured by the A.E.I. LAMP & LIGHTING CO., LTD., Crown House, Aldwych, London, W.C.2. The fitting consists of two aluminium end boxes welded to extruded square section tubes which are in turn welded to a central rectangular control gear box. The lampholders are protected in two end clamp castings and the lamp itself is protected by a toughened glass cylinder. The reflector is made of steel and stove enamelled white internally. The fitting is fully Buxton certified and approved for use in Group II and Group III inflammable gases. This covers most industrial situations, including those in the petro-chemical industries.

Open Blade Micro-Switches

An open blade micro-switch with rolling spring q.m.q.b. action which has a high electrical rating and long working life is reported to be the first of its type to be introduced into this country. It is manufactured by A. F. BULGIN & CO., LTD., By-Pass Road, Barking, Essex.

The switch is designed to be built into apparatus, switching equipment, etc., of all kinds. The switch has pure silver contacts and beryllium copper springs; it is swift in action and has a rating up to 3 A at 250 V. Overall dimensions are 1⅜in by ⅝in. Pre-travel from free position is 5/32in and the nominal contact gap 0·020in.

"Periphonic" Speaker System

The "Periphonic" loudspeaker system, which was shown publicly for the first time at the London Audio Fair on 12th April, embodies entirely new design principles and represents an outstanding advance in high-quality sound reproduction. It has been developed at the Research Laboratories of the GENERAL ELECTRIC CO., LTD.

In the normal way loudspeakers are mounted inside the cabinet. In this system the sound is radiated through a small slot into the cabinet from the peripheries of two metal-cone loudspeakers mounted, one inside the other, in a V-shaped enclosure on the outside of the cabinet. The subsequent "air-coupling" of the two loudspeakers reduces the distortion which occurs with a single speaker, particularly at the bass frequencies, by over 60 per cent.

The complete unit consists of the speaker system and six presence units. The speaker system is mounted on a cabinet which is designed to present the correct acoustic loading to the small slot, and to reproduce faithfully the lower frequencies from 2,000 c/s down to 30 c/s. The presence units cover the frequency range above 2,000 c/s. They are completely sealed at the back so that no sound is radiated from them into the cabinet.

The system takes advantage of the wide arc of distribution of the higher frequencies which is associated with the presence unit. By the use of three separate pairs of units mounted in the front and on each side of the cabinet an effect of spaciousness is given to the sound reproduction. An impression of depth can be produced which particularly enhances orchestral works. By selective switching of the presence units it is possible to vary the nearness of the orchestra to suit individual listening tastes.

Plug-in Time Switch

The new type "K" Mark II time switch, manufactured by the HORSTMANN GEAR CO., LTD., Newbridge Works, Bath, is designed principally for the control of street lighting but has a wide range of other uses including special tariff control. The switch is of the plug-in pattern and is supplied complete with a terminal socket board or can be plugged into existing type "K" terminal boards without alteration to the boards or wiring. A visual running indicator is fitted and the switchgear may be operated manually, if necessary, without interfering with the normal automatic sequence.

The capacity at 250 V 50 c/s is 20 A and the silver cadmium sintered contacts are capable of dealing with their full rated loading of fluorescent, sodium vapour, mercury vapour or tungsten filament lighting.

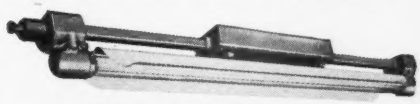
Voltage Stabilisers

A range of a.c. voltage stabilisers, with outputs from 300 VA to 6 kVA, has been introduced by PHILIPS ELECTRICAL, LTD., Century House, Shaftesbury Avenue, London, W.C.2.

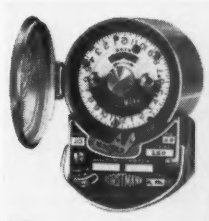
In the 300 VA type, stabilisation is effected by two transformers connected in series, the first having an unsaturated and the second a saturated core. A capacitor is fitted to compensate for load variations. Models are available for 50 or 60 c/s working at 220 V nominal input. The output is within ±1 per cent of 220 V for mains fluctuations from minus 15 per cent to plus 10 per cent. It has no moving parts to require maintenance, weighs only 39 lb, and measures 14½in by 8in by 7in.

Output voltages of the 1, 1·5, 2 and 5 kVA equipment are controlled by a transductor in series with part of the main transformer winding, any slight variation in secondary voltage being eliminated by a bridge circuit and amplifier. A safety relay automatically reduces the secondary voltage if this rises above a certain level.

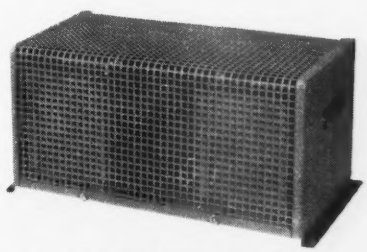
These stabilisers are independent of frequency variation; relatively large fluctuations of power factor in the inductive range do not affect stabilisation, and filters ensure a good sinusoidal shape to the secondary output. The larger stabilisers are available for either 110, 127 or 220 V nominal input at 50 c/s (also 60 c/s in the case of the 5 kVA model). Variations in the mains voltage from −15 per cent to +10 per cent and of ±3 per cent in frequency are permissible for an output within ±0·2 per cent of the nominal voltage. For the 1·5 kVA model, mains voltage fluctuations can be from −30 to +10 per cent.



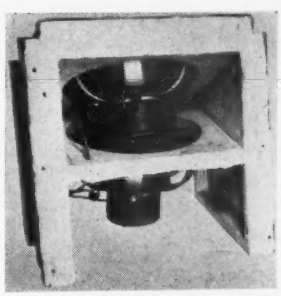
A.E.I. flameproof fluorescent fitting



Horstmann type "K" time switch



Philips P.E. 4205 300 VA voltage stabiliser



G.E.C. "Periphonic" speaker

NEW PATENTS

Electrical Specifications Recently Published

The numbers under which the specifications will be printed and abridged are given in parentheses. Copies of any specification (3s 0d each including postage) will be obtainable after 1st May from the Patent Office, 25, Southampton Buildings, London, W.C.2.

1951

21418. Soc. Anon. des Manufactures des Glaces et Produits Chimiques de St.-Gobain, Chauny & Cirey.—Electric heating elements. 11th September, 1951. (773772.)

1952

18294. Electric & Musical Industries, Ltd. —Target electrodes for electron-discharge devices. 26th June, 1953. (773572.)

20062. Bruel, A. J. Van den.—Circuit arrangements for television sets. 11th February, 1955. (773773.)

24173. Standard Telephones & Cables, Ltd.—Electromagnetic switches. 26th September, 1952. (773683.)

27153. National Research Development Corporation.—Electric switching arrangements. 16th October, 1953. (773872.)

1953

1162. Sperry Corporation. — Phase-measuring and synchronising apparatus. 14th January, 1953. (773670.) 14873. Relay transmission systems. 28th April, 1954. (773576.)

11217. General Electric Co.—Dynamo-electric machine rotors. 23rd April, 1953. (773575.)

18487. English Electric Co., Ltd.—Fixation of tubes for heaters, coolers or the like. 2nd July, 1954. (773578.)

20485. Carbone-Lorraine.—Anodes for powerful electric arcs. 23rd July, 1953. (773579.)

20646. Sparcatron, Ltd., and Rudorff, D. W. A. F.—Methods and apparatus for cutting electrically conductive materials. 7th July, 1954. (773782.)

22494. Standard Telephones & Cables, Ltd.—Travelling-wave electron discharge devices. 14th August, 1953. (773783.)

22817. Electric & Musical Industries, Ltd.—Cathode structures for electron discharge devices. 3rd August, 1954. (773580.)

25960. Daimler-Benz Akt.-Ges.—Electrical instruments for measuring rotary oscillations. 21st September, 1953. (773582.)

26120. General Electric Co.—Silicone water repellents. 22nd September, 1953. (773974.)

28473. Kelvin & Hughes, Ltd.—Remote indicating apparatus. 11th October, 1954. (773976.)

31880. General Electric Co.—Electric terminals. 17th November, 1953. (773787.)

33434. Electric & Musical Industries, Ltd.—Magnetic deflecting systems for cathode-ray tubes. 26th November, 1954. (773585.)

1954

6276. General Tire & Rubber Co.—Insulated electrical conductors and method of making same. 3rd March, 1954. (773969.)

7000. Elecontrol, Ltd.—Proximity switch. 10th March, 1955. (773982.)

8139. Metropolitan-Vickers Electrical Co., Ltd.—Electronic amplifier circuit arrangements. 15th April, 1955. (773984.)

10223. Imperial Chemical Industries, Ltd.—Electrolytic cells. 6th April, 1955. (773791.)

10398. Wayne Kerr Laboratories, Ltd., and Calvert, R.—Electrical measuring apparatus. 6th July, 1955. (773985.)

10825. Electric Machinery Mfg. Co.—Electrostrictive relays. 13th April, 1954. (773888.)

11483. McMurdo Instrument Co., Ltd., and Coates, L. K.—Electric contact devices. 21st April, 1955. (773889.)

11598. Electric & Musical Industries, Ltd.—High frequency apparatus. 12th April, 1955. (773988.)

15265. British Insulated Callender's Cables, Ltd.—Manufacture of electric capacitors of the wound type. 23rd May, 1955. (773796.)

17041. Ferranti, Ltd.—TR cells. 8th June, 1955. (773600.)

17378. Murex Welding Processes, Ltd.—Arc welding electrodes. 14th June, 1955. (773994.)

19529. Sylvania Electric Products, Inc.—Electroluminescent lamps. 2nd July, 1954. (773997.)

20824. Edison Swan Electric Co., Ltd.—Conduits or casings for indoor and like electric wiring. 11th July, 1955. (773605.)

23522. Chromatic Television Laboratories, Inc.—Television tube grid structure. 13th August, 1954. (773805.)

24953. Siemens Bros. & Co., Ltd.—Circuit arrangements for the generation of electric pulses. 18th November, 1955. (773609.)

27871. Telephone Manufacturing Co., Ltd.—Audio-frequency signalling arrangements in multiflex carrier wave telephone systems. 21st September, 1955. (773687.)

27879. Welwyn Electrical Laboratories, Ltd.—Electrical condensers. 27th September, 1954. (774009.)

30845. International Business Machines Corporation.—Transistor logical circuits. 26th October, 1954. (773962.)

31307. Igranic Electric Co., Ltd.—Electromagnetically operated switch units. 29th October, 1954. (774012.)

31589. Telefunken Ges., formerly Telefunken Ges. für Drahtlose Telegraphie.—Frequency changing mixing circuits. 2nd November, 1954. (774015.)

32695. Burtt, H. H.—Locking mechanism for electrical plug-and-socket connectors. 11th November, 1954. (773619.)

33224. Siemens & Halske Akt.-Ges.—Impulse storage mechanism for telecommunication installations. 16th November, 1954. (773902.)

33436. Philips Electrical Industries, Ltd. —Television camera tubes. 18th November, 1954. (773813.)

33466. General Electric Co., Ltd.—Electric cable trunking. 18th November, 1955. (773621.)

34603. Automatic Telephone & Electric Co., Ltd.—Telephone systems. 29th September, 1955. (773623.)

35095. General Electric Co., Ltd.—Electric motor control systems. 28th November, 1955. (773624.)

35795. Standard Telephones & Cables, Ltd.—Circuit arrangement to couple signals in two different frequency bands. 10th December, 1954. (773817.)

36287. International Business Machines Corporation.—Logical circuits employing junction transistors. 15th December, 1954. (773963.)

1955

2649. Research Corporation.—Electrostatic precipitators. 28th January, 1955. (773694.)

2712. Siemens & Halske Akt.-Ges.—Telecommunication submarine cables having repeaters installed at intervals. 28th January, 1955. (774026.)

2814. Aktiebolaget Elektrolux.—Clothes washing machines. 17th December, 1952. (773674.)

3616. Sylvania Electric Products, Inc.—Multiple flash lamp apparatus. 7th February, 1955. (774027.)

5336. Polytechnic Institute of Brooklyn.—High frequency impedance measuring devices. 22nd February, 1955. (773699.)

6092. Smit & Co.'s Transformatoren-Fabriek N.V., W.—Tap changing switches provided with bridging resistance for transformers. 1st March, 1955. (773830.)

7269. British Insulated Callender's Cables, Ltd.—Repair of insulated electric conductors. 12th March, 1956. (773832.)

8162. Hazeltine Corporation.—Colour television image reproducing apparatus. 21st March, 1955. (773706.)

8865/6. Compagnie Générale de Télégraphie sans Fil.—Backward travelling wave oscillator tubes. 25th March, 1955. (773708/9.)

10566. Magnetron tubes having adjustable frequency. 12th April, 1955. (773710.)

12183. Electron wave tubes. 27th April, 1955. (773834.)

9312. Sperry Corporation.—Phase detectors using transistors. 30th March, 1955. (774038.)

9637. Blackburn & General Aircraft, Ltd., Saunders, C. G., and Piper, R. H.—Vibratory electric coils. 16th February, 1956. (773911.)

12242. Bosch Ges., R.—Pressure or temperature actuated electric switches. 28th April, 1955. (773712.)

12510. Standard Telephones & Cables, Ltd.—Operator's telephone headsets. 29th April, 1955. (773912.)

13507. Hilfiker, H., and Schreiber, A.—Electrical distribution boards. 10th May, 1955. (773715.)

14200. International Business Machines Corporation.—Transistor and electron-discharge tube trigger circuit. 17th May, 1955. (774045.)

14471. Soc. Anon. pour les Applications de l'Electricité et des Gaz Rares-Etablissements Claude-Paz & Silva.—Method for manufacturing a hollow electron emissive electrode. 19th May, 1955. (774046.)

14861. Gialluly, E. M. S. de.—Vibratory converters for converting direct to alternating current or vice versa. 23rd May, 1955. (773917.)

16772. Hartmann & Braun Akt.-Ges.—Electrical condensers having gaseous dielectrics. 10th June, 1955. (774050.)

16814. Standard Telephones & Cables, Ltd.—Solid-state radiation amplifier. 10th June, 1955. (774051.)

17895. Westinghouse Electric International Co.—Electrostatic precipitators. 21st June, 1955. (774055.)

18501. Philips Electrical Industries, Ltd. —Blocking-layer semi-conductor devices. 27th June, 1955. (774057.)

19084. Western Electric Co., Inc.—Apparatus for moulding blocks of plastic material on wires in the manufacture of components of multi-contact electromagnetic relays. 1st July, 1955. (773837.)

19910. Telefonaktiebolaget L. M. Ericsson.—Contact devices for electrical switching apparatus. 8th July, 1955. (773734.)

20225. Bosch Ges., R.—Commutator manufacture. 13th July, 1955. (773921.)

20582. General Electric Co.—Steam irons. 15th July, 1955. (773741.)

21409. Electrolux, Ltd. — Vacuum cleaners. 25th July, 1955. (773745.)

21511. Nihon Shinku Tokei Kabushiki Kaisha.—D.c. motors. 25th July, 1955. (773747.)

21706. Soc. Erec Soc. d'Etudes, de Realisations et d'Exploitations Commerciales.—Self-priming electric batteries. 27th July, 1955. (773752.)

22296. Philips Electrical Industries, Ltd. —Transistor amplifiers. 3rd August, 1955. (773754.)

23081. General Electric Co.—Refrigerators. 10th August, 1955. (773927.)

23435. Research Corporation.—Electrostatic precipitators. 15th August, 1955. (773930.)

23436. Research Corporation.—Control means for electrostatic precipitators. 15th August, 1955. (773631.)

[*Continued on p.* 795

CONTRACT INFORMATION

Accepted Tenders and Prospective Electrical Work

CONTRACTS OPEN

Where "Contracts Open" are advertised in our "Official Notices" section the date of the issue is given in parentheses.

Australia.—State Electricity Commission of Victoria, Melbourne. 5th June. One 35/45 MVA transformer and spares. (E.S.B. 9206/57. Ten/25312.)*

Belgian Congo.—14th May. Electrical central heating, kitchen and laundry equipment. (E.S.B. 9627/57. Ten/25408.)*

Burma.—Union of Burma Purchase Board. 2nd May. Electric stove for baking enamel. (E.S.B. 9731/57. Ten/25347.)*

Cheltenham.—Borough Council. 13th May. Supply and erection of group "A" sodium discharge lighting installations in five streets in the borough. G. Gould Marsland, borough engineer, Municipal Offices.

India.—Bombay Electricity Board. 25th June. Galvanised steel towers and insulators. (E.S.B. 9242/57. Ten/25318.)*

Korea.—Government Office of Supply, Seoul. 15th May. Stores, including thirty 200 A, 600 V circuit-breakers, and switchgear. (E.S.B. 9495/57. Ten/25282.)*

New Zealand. — Wellington Electricity Department. 2nd May. 11 kV and 1,100 V cable. (E.S.B. 9765/57. Ten/25376.)*

Stores Division, G.P.O., Wellington. 24th May. Grinding attachment, portable grinder, vices and electric drills. (E.S.B. 9167/57. Ten/25310.)*

Portuguese East Africa.—Government Purchasing Commission, Lourenço Marques. 6th May. Diesel generating set. (E.S.B. 10111/57. Ten/25434.)* 8th May. Ten electric motors, starter and circuit-breaker. (E.S.B. 10112/57. Ten/25433.)*

Rhodesia and Nyasaland.—Federal Tender Board. 3rd May. Insulated copper wire. (E.S.B. 9471/57. Ten/25320.)*

St. Albans.—City Council. 13th May. Street lighting equipment. (See this issue.)

South Africa.—Durban Electricity Department. 3rd May. Insulators and arcing horns. (E.S.B. 9191/57. Ten/25294.)* 33 kV underground cables and joints. (E.S.B. 9193/57. Ten/25323.)*

Stores Department, South African Railways. 8th May. Telegraph line material. (E.S.B. 9925/57. Ten/25431.)* 10th May. Telegraph line material. (E.S.B. 9610/57. Ten/25366.)*

Union Tender and Supplies Board, Pretoria. 16th May. Stores, including electric drills. (E.S.B. 9528/57. Ten/25357.)*

Southend-on-Sea.—Corporation. 9th May. Electrical installation in Hamlet Court Junior Mixed School. (See this issue.)

Thailand.—Post and Telegraph Department. 7th May. Two 200 kVA diesel generator sets. (E.S.B. 9442/57. Ten/25299.)* 17th May. Underground and overhead cables. (E.S.B. 9441/57. Ten/25308.)*

Trinidad.—Trinidad and Tobago Electricity Commission. 15th May. Transformers ranging from 50 kVA to 250 kVA. (E.S.B. 9776/57. Com/13346.)*

ORDERS PLACED

Dudley.—Corporation Streets, Transport and Lighting Committee. Recommended. Supply and erection of Stanton spun concrete lighting columns (£27,815) and provision of the necessary cables and connecting new lamps to the mains, forming the first year's programme of the five year scheme for street lighting (£9,549).—Midlands Electricity Board.

London. — Metropolitan Water Board Works and Stores Committee. Recommended. High voltage switchgear, transformers and ancillary equipment for Ferry Lane pumping station in connection with the Thames to Lee Valley water main (£17,418).—Brush Electrical Engineering Co.

Peterborough.—Corporation Housing Construction and Slum Clearance Committee. Electrical installations in 124 houses and 34 bungalows on the Bluebell and Park Lane estates (£3,294).—M. F. Hansen.

Sheffield. — Regional Hospital Board. Recommended. Improvements to the electrical services at the Middlewood Hospital (£6,813).—Barr's (Sheffield).

South Shields.—Corporation. Electrical work at the new South Shields Marine and Technical College (second instalment) (£19,232).—R. H. Patterson.

Stockton-on-Tees.—Corporation. Recommended. Electrical work in 58 houses and 16 bungalows being erected at Hardwick (£2,921).—A. Rose.

NEW PATENTS (*Continued from page 794*)

23599. Philips Electrical Industries, Ltd. —Circuit arrangements for current supply to electron tubes. 16th August, 1955. (773970.)

24353. British Thomson-Houston Co., Ltd.—Circuit arrangements for regulating transformers. 24th August, 1955. (773759.)

24444. Rosenthal-Isolatoren Ges. — Arrangement for supporting an electric overhead line insulator. 25th August, 1955. (773634.)

24461. Paillard Soc. Anon.—Electric type printing and like office machines. 25th August, 1955. (773939.)

24515. Siemens-Schuckertwerke Akt.-Ges.—Control sets for gas or vapour-filled electric-discharge vessels. 25th August, 1955. (773635.)

25204. Hoover, Ltd.—Suction cleaners. 1st September, 1955. (773763.)

26156. Heggen, O.—Electric switching device responsive to the rotational or oscillatory motion of a number. 13th September, 1955. (773641.)

27345. Standard Telephones & Cables, Ltd.—Piezo-electric crystal constructions. 26th September, 1955. (773644.)

27877. Western Electric Co., Inc.—Telephone set circuits. 30th September, 1955. (773850.)

28224. Westinghouse Air Brake Co.—Electromagnetic relays. 4th October, 1955. (773852.)

33734. Canadian General Electric Co., Ltd.—Salient pole dynamo electric machines. 24th November, 1955. (773665.)

33910. Smit & Co.'s Transformstoren-Fabriek N.V., W.—Magnetic core structures. 25th November, 1955. (773666.)

35457. Lewus, A. J.—Control systems for induction motors of the capacitor type. 9th December, 1955. (773866.)

35745. Aero Materiel Aktiebolaget.—Electrical generators. 13th December, 1955. (773867.)

37264. General Electric Co.—Thermally protected electric motors of the dual voltage type. 29th December, 1955. (773945.)

WORK IN PROSPECT

Particulars of new works and building schemes for the use of electrical installation contractors and traders. Publication in this section is no guarantee that electrical work is definitely included. Alleged inaccuracies should be reported to the Editors

Aberystwyth.—Biology building (£300,000) for University College of Wales; Lucas & Pyke, electrical consultants, 25, Caxton Street, London, S.W.1.

Birmingham.—Extensions to Medical School, for University Senate; Lanchester & Lodge, architects, 10, Woburn Square, London, W.C.1.

Boreham Wood.—Works; Metal Box Co., Ltd., 37, Baker Street, London, W.1.

Bournemouth.—Grammar school for girls, Castle Lane (£250,000); W. L. Clowes, borough surveyor, Town Hall.

Bristol.—Factory, Ashton Gate; Strachan & Henshaw, Ltd., Whitehall Road.

Warehouse and offices, Broadmead; Shirley Bros., Ltd., Lower Castle Street.

Chailey.—Nurses' home, Heritage Hospital; Scannell & Manby, surveyors, 87, Chancery Lane, London, W.C.2.

Cheltenham.—Dwellings (57), Dowty Road; borough surveyor.

Coalville.—Grammar school (£212,600); county architect, Leicester.

Croydon.—Factory extensions, Purley Way; Stewart Plastics, Ltd., 45, Merrish Road, London, S.W.2.

Doncaster.—New Curlew School (£34,933); borough architect.

Dorking.—First phase of Sondes Place County Secondary Boys' School (£64,089); J. Harrison, county architect, County Hall, Kingston-on-Thames.

Edmonton.—Factory, Langhedge Lane; A. Knifton, Ltd., 117b, Fore Street, London, N.18.

Enfield.—Five-storey flats, South Street; borough engineer.

Factory, Southbury Road; Spencer, Heath & George, Ltd., Gymnastic Works, Garfield Road.

Frome.—Houses (70); clerk to R.D.C., Christchurch Street West.

Godalming.—Factory, Catteshall Road; Ingram & Glass, Ltd., Ingla Works, Weydown Road, Haslemere.

Harlow.—Dwellings (128), Tye Green; Architects' Department, Development Corporation, Terlings, Gilston.

Factory, Temple Fields; Newman & Guardia, Ltd., 60, Berners Street, London, W.1.

Horley. — Replacement of mechanical services, Farmfield Hospital, Charlwood; Harding, McDermott & Partners, consultants, 18, Doughty Street, London, W.C.1.

Hove.—Flats (40), Hangleton Road; T. R. Humble, borough engineer, Town Hall.

Hull.—First instalment of scheme for new library at University (£300,000); W. A. Forsyth & Partners, architects, 47, Nottingham Place, London, W.1.

Jarrow.—R.C. church, York Avenue (£21,000); Gunning & Co., builders, Hannington Street, Newcastle-on-Tyne.

Kerrier.—Houses (60), Mabe Burnthouse; W. Thomas, clerk to R.D.C., The Willows, Helston, Cornwall.

Kingston-on-Thames.—Flats, New Road; Brewer, Smith & Brewer, architects, 38, Thames Street.

Leeds.—Synagogue, Street Lane; J. G. L. Poulson, architect, 29, Ropergate, Pontefract.

Leicester.—New laboratories at Wyggeston Boys' School (£66,000); city architect.

Long Ashton.—Houses (55), Southfield Road, Nailsea; M. Froud & Stevens, architects to R.D.C., 1, St. Stephens Chambers, Bristol, 1.

Manchester.—Terminal buildings for City Airport; city architect.

Office block, Cannon Street, Corporation Street and Old Millgate; Harry S. Fairhurst & Son, architects, 55, Brown Street.

Market Harborough.—Grammar school extensions (£59,000); county architect, Leicester.

Mitcham.—Two-storey offices, Watts Yard, Upper Green East; Randalls (Wimbledon), Ltd., 116, Merton High Street, London, S.W.19.

Newcastle-on-Tyne.—Bottling factory for Newcastle Breweries, Ltd. (£600,000); Sir R. McAlpine & Sons, builders, 81, Jesmond Road.

Houses (233), Denton Dene; G. Kenyon, city architect, 18, Cloth Market.

Northampton.—Extensions to College of Further Education; Edward A. Pearce & Partners, consulting engineers, 28, Baker Street, London, W.1.

Dwellings (34), Kings Heath; Adkins & Shaw, Ltd., builders, St. James Road.

Nuneaton.—Flats (64), Coton Road; Fredk. Gibberd, architect, 8, Percy Street, London, W.1.

Oadby. — Secondary modern school (£168,100); county architect, Leicester.

Ossett.—Houses (144), Broadowler estate; B. Freeman, town clerk, Town Hall.

Peterborough.—Houses (84), Bluebell estate; city architect.

Pinner.—Houses (100), Blythwood estate; H. W. Porritt, Ltd., Blythwood Road.

Ponteland (Northumberland).—C. of E. school (£133,000); John Jackson & Sons, contractors, Corporation Street, Newcastle-on-Tyne.

Portchester. — Crematorium, Cornaway Lane; V. Blanchard, City Council Chambers, 1, Clarence Parade, Portsmouth.

Reigate.—Houses (37), Park House site, Park Lane East; H. Davies, town clerk, Town Hall.

Ross-on-Wye.—Erection of annexe to The Chestnuts (£34,160); county architect, Bath Road, Hereford.

Salford.—Science wing for De La Salle College; Gilbert-Ash, Ltd., builders, Kirkby Estate, Kirkby, near Liverpool.

Scraptoft. — Secondary modern school (£210,000); county architect, Leicester.

South Shields.—Infants' schools in the Whiteleas and Highfield Road areas; Page, Son & Hill, architects, 75, King Street.

Stamford.—Central laundry at Stamford and Rutland Hospital; Peterborough and Stamford Hospital Management Committee, Peterborough.

Stockport.—Science block, Avondale Secondary Modern School; borough architect.

Sunderland.—New schools at Seaburn, Pennywell, Broadway, Southwick, and additions to Bede Grammar School (1958-59 programme); H. C. Bishop, borough architect, Grange House, Stockton Road.

Health centre, Murton Street (£23,000); borough architect.

Houses (136) and flats (10), Hylton Red House estate; W. Veti, Ltd., builders, Foyle Street.

Surbiton.—Rebuilding Southampton Hotel, St. Mark's Hill; Tiltman & Howard, architects, 38, East Street, Brighton.

Walsall.—Shopping arcade in Park Street; City & Town Buildings, Ltd., 74, Old Christchurch Road, Bournemouth.

Warrington.—Rebuilding police training centre, Bruche; McLellan & Partners, consulting engineers, 32, Victoria Street, London, S.W.1.

Dwellings (101), off Chester Road; Milton Hindle, Ltd., 19, Queen Street, Blackpool.

Warsop.—Houses (30), Sandy Lane; U.D.C. surveyor, Town Hall.

West Hartlepool.—New works on the site of Greatham Airport for South Durham Steel and Iron Co., Ltd., Middlesbrough.

NEXT WEEK'S EVENTS

Organisers of electrical functions are advised to make use of the "Electrical Review" clearing house, Room 221, Dorset House, Stamford Street, London, S.E.1, to ascertain that proposed dates do not clash with others already arranged.

Monday, 29th April

BIRMINGHAM.—James Watt Institute, Great Charles Street, 6 p.m. I.E.E. South Midland Radio and Telecommunication Group. Annual general meeting.

LONDON.—Savoy Place, W.C.2, 5.30 p.m. I.E.E. Radio and Telecommunication Section. Informal evening on "Radio in Air-Sea Rescue." Talks by G. W. Hosie, D. Kerr and W. Kiryluk.

Monday, 29th April, to Saturday, 4th May

LONDON.—Earls Court. Factory Equipment Exhibition.

Tuesday, 30th April

EDINBURGH.—Carlton Hotel, North Bridge, 7 p.m. I.E.E. South-East Scotland Sub-Centre. Annual general meeting followed by "Applications of Magnetic Amplifiers" by C. Cowan and "Stereophonic Sound" by G. I. Thomas.

GLASGOW.—425, Sauchiehall Street, C.2, 7 p.m. Institution of Heating and Ventilating Engineers, Scottish Branch. Annual general meeting followed by "Air Conditioning in the British Isles," by J. C. Knight.

LONDON.—At the I.E.E. Savoy Place, W.C.2, 6.30 p.m. Plastics Institute. "Thermoplastics in the Submarine-Cable Industry," by Sir John Dean.

85, Minories, E.C.3, 5.30 p.m. Institute of Marine Engineers. Annual general meeting.

Manson House, Portland Place, W.1, 6.30 p.m. Society of Instrument Technology, Ltd. London meetings. "The Preparation and Industrial Applications of Diffraction Gratings" by Dr. L. A. Sayce.

May Fair Hotel, W.1. Institution of Chemical Engineers. 35th annual corporate meeting and dinner.

Tuesday, 30th April, to Thursday, 2nd May

EASTBOURNE.—Public Transport Association. Annual conference.

LONDON.—1, Birdcage Walk, Westminster, S.W.1. Institution of Mechanical Engineers. Conference on "Properties of Materials at High Rates of Strain."

Wednesday, 1st May

GLASGOW.—At the Institution of Engineers and Shipbuilders, Elmbank Crescent, 7 p.m. I.E.E. South West Scotland Sub-Centre. Annual meeting. "The Early Development of Radar," by Miss S. McL. Weir.

LONDON.—Savoy Hotel, 12.30 for 1 p.m. Electrical Research Association. Annual luncheon, preceded by the annual general meeting.

NORTHAMPTON.—College of Technology, 7.15 p.m. Northampton and District Electrical Association. Annual general meeting.

PRESTON.—19, Friargate, 7.15 p.m. I.E.E. North Lancashire Sub-Centre. Annual general meeting. "The Television Studio as seen by the Producer," by Alvin Rakoff.

R.A.F.A. Club, East View, 7.30 p.m. A.S.E.E. Preston Branch. "Emergency Lighting Equipment," by A. S. Wolstenholme.

STAFFORD.—Technical College, 7.15 p.m. I.E.E. North Staffs Sub-Centre Graduate and Student Section. Annual general meeting.

Thursday, 2nd May

BIRMINGHAM. — I.E.E. South Midland Education Discussion Circle. Visit to new electrical laboratories, College of Technology, Gosta Green.

BRISTOL.—Bristol University, 7 p.m. I.E.E. Bristol Graduate and Student Section. "2/1 Pole Changing Induction Motors," by R. F. Burbidge.

LONDON.—Connaught Rooms, W.C.2, 12.30 for 1 p.m. Diesel Engineers' and Users' Association. Annual luncheon.

NOTTINGHAM.—Electricity Service Centre, Smithy Row, 5.30 p.m. I.E.S. Nottingham Centre. Annual general meeting.

Friday, 3rd May

LIVERPOOL.—24, Dale Street, 7.30 p.m. A.S.E.E. Liverpool Branch. Electrical Installation in Modern Cargo Vessel," by A. Robertson.

LONDON.—1, Birdcage Walk, S.W.1, 6 p.m. Institution of Mechanical Engineers. "The Influence of Dynamical Imperfection on the Vibration of Rotating Disks," by Dr. S. A. Tobias and Prof. R. N. Arnold, and "Free Undamped Non-linear Vibrations of Imperfect Circular Disks," by Dr. S. A. Tobias.

Connaught Rooms, W.C.2. Institution of Engineers-in-Charge. Annual dinner (reception 6 p.m.). Principal guest, Lord Mills.

MANCHESTER.—The University, 5.30 p.m. Manchester Federation of Scientific Societies. Annual meeting and dinner.

Saturday, 4th May

LONDON.—Victoria Halls, W.C.1, 7.30 p.m. I.E.E. London Graduate and Student Section. Spring dance.

TRADE MARK APPLICATIONS

APPLICATIONS have been made for the registration of the following trade marks. Objections may be entered up to 3rd May:—

D. (design). No. 757,873. Class 7. Starting devices for electric motors (not land vehicles). D. (design). No. 738,075. Class 9. Electric switches, electric circuit breakers, electric switchgear; instruments for the testing, checking and verification of electrical instruments; fitted electrical switchboards; electrical instruments for measuring and indicating; electrical apparatus for use in operating machines, engines and motors by current control; fitted electric terminal blocks, electric transformers, electric resistances, solenoid operated valves, electrical contacts and electromagnets.—Square D. Co., Milwaukee 12, Wisconsin, U.S.A. Address for service, c/o W. E. P. Bayly, c/o Plessey Co., Ltd., 56, Vicarage Lane, Ilford, Essex.

HOTPOINT DUCHESS. No. 760,662. HOTPOINT EMPRESS. No. 760,663. Class 7. Washing machines. — Hotpoint Electric Appliance Co., Ltd., Crown House, Aldwych, London, W.C.2.

MELTRONIC. No. 744,610. Class 9. Transformers, chokes and inductors, all being electric.—Melton Electronics, Ltd., 387-389, Ashley Road, Parkstone, Poole, Dorset.

OOR WULLIE. No. 761,181. Class 9. Cinematograph films prepared for exhibition; television and radio instruments and apparatus; sound reproducing and sound recording instruments and apparatus; and optical projection instruments and apparatus; and parts.—D. C. Thomson & Co., Ltd., Couriers Buildings, Albert Square, Dundee.

VESTA. No. 751,297. Class 10. Electrically heated blankets; and electrically heated pads for warming and airing beds.—Thomas French & Sons, Ltd., Chester Road Mills, Chester Road, Manchester, 15.

PYRAD. No. 757,261. Class 11. Electric heating installations and apparatus; and domestic electric appliances.—Pye, Ltd., Radio Works, St. Andrews Road, Cambridge.

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